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JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

DEVOTED TO

MECHANICAL AND PHYSICAL SCIENCE,

Civil Engineering, the Arts and Manufactures.

EDITED BY

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JANUARY, 1862.

CIVIL ENGINEERING.

Report on Decay of the Stone at the New Palace at Westminster.

From the London Builder, No. 974.

THE report of the committee appointed by the First Commissioner of Her Majesty's Works and Public Buildings, to inquire into the decay of the stone of the New Palace at Westminster, and into the best means for preserving the stone from further injury, with the minutes of evidence, has been published as a "Return to an Order of the Honorable the House of Commons, dated the 1st of August, 1861," and can be obtained by the public in the usual way. The committee met thirteen times (between March 23d and August 7th), irrespective of the meetings of sub-committees; examined thirty-one witnesses; and considered seventy-seven communications submitted to them. The following, addressed to the Right Hon. Wm. Cowper, M. P., is their

REPORT:

Sir:—We, the undersigned, being the committee appointed "to inquire into the decay of the stone of the New Palace of Westminster, and into the best means of preserving the stone from further injury," have the honor to submit to you the following report, in which we have adopted, as the objects of our inquiry, the several points referred to by your letter of appointment and instruction,* viz:—

"I. The extent and position of the decay.

* The letter of appointment and instruction was addressed:—"To Sir Roderick Impey Murchison, G.C.St.S., D.C.L., LL.D., F.R.S., Director-General of the Geological Survey of Great Britain; William Tite, Esq., M.P., F.R.S., President of the Royal Institute of British Architects; Sydney Smirke, Esq., Royal Academician, Architect; George Gilbert Scott, Esq., Royal Academician, Architect; Geo. Godwin, Esq., F.R.S., and Matthew Digby Wyatt, Esq, Vice Presidents of the Royal Institute of British Architects; Augustus William Hofmann, Esq., LL.D., F.R.S., Professor of the Royal College of Chemistry; Edward Frankland,

"II. The causes to which it is attributable, taking into consideration the composition of the stone, and the influence exerted upon it by moisture, and by the acids diffused in the London atmosphere.

"III. The best means of preserving the stone from further injury."

"IV. The qualities of the stones to be recommended for future use in public buildings to be erected in London."

1. In proceeding with the important inquiry thus entrusted to this committee, we beg to state that we first made a careful inspection of the whole of the buildings; and that after this inspection we proceeded to obtain such evidence as appeared to us best calculated to facilitate the inquiry entrusted to us, by examining a considerable number of witnesses who had been connected with the building from the commencement, or who had been concerned in the various processes which had been actually tried for arresting the decay which had occurred; and also another class of witnesses, who had suggested various theoretical remedies for the same purpose.

2. We delegated to a sub-committee, specially appointed, an examination and inquiry into the condition of other buildings erected in the metropolis, in which magnesian limestone had been used; and we particularly called the attention of the scientific chemists, who had been appointed on the committee, to several points peculiarly within the limits of their acquaintance with chemical subjects.

3. We also considered it expedient to invite by advertisement the attention of chemists and others to the subject submitted to the committee; requesting that any plan or suggestion for the prevention of decay, or for arresting its progress, might be brought under our notice.

4. Having thus premised the course the committee thought it expedient and desirable to take, we now proceed to report *seriatim* on the subjects brought under our notice by your instructions, and in the order adopted therein.

I. The Extent and Position of the Decay.

5. It is extremely difficult to give any very exact account either of the extent or actual position of the decay. It seems from the evidence that it first began to make its appearance in the portions of the Palace at Westminster executed at the commencement of the building about seven years after their execution; and yet, in some of the most recently executed portions, viz: those towards Old Palace-yard, facing Henry VII.'s Chapel, the decay appears to be as obvious as in any other part of the building.

6. In the earlier works, viz: those towards the Thames, the decay is most apparent in the lower portion of the building; and in this portion the decay is confined to what may be called "zones," or general levels; which would seem to suggest that it depends as much upon po-

Esq., F.R.S., Professor of Chemistry at St. Bartholomew's Hospital; Frederick Augustus Abel, Esq., F.R.S., Chemist to the War Department; David Thomas Ansted, Esq., M.A., F.R.S., Professor of Geology; James Tennant, Esq., Professor of Geology at King's College, London; George Rowdon Burnell, Esq., Civil Engineer; Thomas Hawksley, Esq., Civil Engineer; Charles Harriott Smith, Esq., one of "the Commissioners for the selection of the stone for building the Houses of Parliament;" and Edward Middleton Barry, Esq., Associate of the Royal Academy, and Architect in charge of the houses of Parliament; the committee appointed by the First Commissioner of Her Majesty's Works and Public Buildings to inquire into the decay of the stone of the New Palace at Westminster, and into the best means for preserving the stone from further injury." Mr. Alfred Bonham-Carter acted efficiently as Secretary.

sition in the building as upon the use of particular beds of stone from the quarries employed.

7. The same remark applies to the part of the palace fronting the approaches to Westminster Bridge, where the decay of the lower portion is considerable; but, in the newest work, facing Henry VII.'s Chapel, the decay occurs in positions which are more varied, and under circumstances which it is exceedingly difficult to appreciate.

8. We have examined with much care the upper portions of the building; and we cannot perceive that the decay has made any important inroad upon those much more exposed portions, where decay might more reasonably have been expected. The decay, however, occurs again to a considerable extent in the inner courts, which are sheltered in a great measure from external influences; and, perhaps, the very worst specimen we have noticed is to be found in the small archway leading to the reporters' gallery, near the entrance to Westminster Hall; a part of the work as much sheltered as in the nature and circumstances of a public building it could well be.

9. The general result of our observations, confirmed by the evidence, would seem to suggest that the stone used in the Palace of Westminster is much more likely to decay in damp and sheltered situations than where it is exposed to the full action of atmospheric influences. In the east and north fronts, before adverted to, the worst symptoms occur in the ashlar between the upper and lower mouldings of the plinth, and under the first cornice, where the exposure is inconsiderable; but the dampness, arising from the drip of the mouldings and from the action of capillary attraction, in cases where projections hold the moisture, appears to exercise an important influence on the condition of the stone itself.

10. It does not appear to us that the decay is attributable, as is commonly supposed, to the stones in the building not being placed upon what is technically called their natural bed, or in the same relative position as they occupied in the quarry: thus, stones which are found horizontally in the quarry appear to have been often placed perpendicularly in the building, and used for purposes of the most delicate decoration without any injurious result. As an instance of this fact, we may point out the elaborately carved shields of arms under the range of the first-floor windows: the stones used for these shields, though universally placed perpendicularly to their natural position in the quarry, present, so far as we are aware, few, if any, symptoms of decay.

11. The extent to which the decay on the whole surface has proceeded, it is not very easy to estimate. At the present moment the actual decay is, doubtless, considerable for a building so recently erected; but the change of color in the stone itself, and the "fretting out of the surface," which are suggested as the first symptoms, lead us to apprehend that there may exist much more mischief than at present is actually apparent.

12. One of the witnesses examined, however, and whose judgment as a practical man is of considerable value, is of opinion that the decay,

after proceeding to some depth in the stone, stops of itself; that an induration of the surface takes place, and that no further decay ensues. The committee would willingly accept this opinion, if they considered it well founded; but they cannot conceive that it is true to any considerable extent, notwithstanding there may certainly be some few indications which lead to the belief that in some cases it may be correct.

13. At present the decay appears for the most part on the plain surfaces, whilst the finer and more elaborately-wrought portions of the building, unless under projections, are not seriously affected. And, however disappointing and disfiguring these defects may be, especially in a building so recently erected, the committee are of opinion that at present the decay does not affect the stability of the structure.

II. The Causes to which the Decay is Attributable.

14. This part of the inquiry naturally leads to a reference to the evidence which has been obtained by the committee on the subject of the stone itself. The result of this evidence may be thus briefly stated. The stone recommended by the commissioners for this building was that from the quarries of Bolsover Moor and its neighborhood; and this stone was actually contracted for in the first instance. Before the work began, however, it was found that blocks of sufficient size could not be procured from those quarries; and in consequence, one of the commissioners was appointed to proceed to the spot, to ascertain whether other quarries might not be discovered furnishing stone in beds of greater thickness and of larger dimensions. These conditions were found in the quarries of Anston, and the stone of greater thickness procured from these quarries has been used not only in this building, but in all the other buildings constructed of magnesian limestone in the metropolis, after the quarries of Bolsover Moor had been abandoned, for the reason above stated.

15. The recommendation of the Bolsover stone in the report of the commissioners was founded on its similarity to that used in the Norman portions of Southwell Minster, which were stated in the report to be in a high state of preservation. Evidence has since been adduced, in a letter from Mr. Scott, to be found in the Appendix, which renders it probable that the stone of this Minster was really obtained from the ancient quarries at Mansfield Woodhouse. The latter quarries were re-opened, and a considerable quantity of stone from them (exceeding 20,000 cubic feet) was made use of in the Palace of Westminster; but in their turn they were relinquished, from dissatisfaction as to the size of the blocks, though we have it on evidence, confirmed by our own observation, that the stone used from these quarries has stood remarkably well.

16. The evidence brought before your committee on the subject of the stone obtained from the Anston quarries is very conflicting; the contractor and his principal foreman stating that the stone was, with slight exceptions, extraordinarily good; while other witnesses maintain that even in the quarries themselves there are stones in a state of ac-

tual decomposition; and one very important witness, a foreman employed at the Palace at Westminster, asserts he knew that certain beds in some of the quarries were liable to decay, and that he abandoned them in consequence. With reference to the selection of stone, the committee venture to remark, that it is much to be regretted that the offer made by one of the commissioners, particularly well acquainted with the selection and working of stone, to examine that used in the Palace at Westminster for the moderate salary of £150 per annum, was not accepted; owing to some difficulty in regard to the party who was to be held responsible for this unimportant amount; and that the matter was left to persons who admit they had little or no prior experience of this description of stone, though they evidently entertained suspicions of the durability of some of it which they were employing.

17. With reference to the very natural and important question of the actual causes of the decay of this stone when exposed to the London atmosphere, the committee take the liberty of referring to the report of the chemists, who were members of the committee, to whom this question was specially referred. This will be found in the Appendix.

III. The Best Means of Preserving the Stone from further Injury.

18. This part of the inquiry referred to the committee naturally divides itself into two questions; namely, as to the steps that have hitherto been taken, whether experimentally or otherwise; and as to those that are to be recommended for adoption hereafter. With regard to the first question, we have ourselves examined with care the result of what has been done at the Palace itself, either experimentally on the river front, or, as in the inner courts, by actual coatings or washings over large surfaces. With regard to the second question, our inquiries have been earnest and elaborate, and we have examined many witnesses and given much time to the consideration of the various propositions obtained by advertisement or otherwise. As will be seen in a subsequent part of the report, we finally referred this question to the further consideration of the professional chemists who were on the committee.

19. On the first question, the committee are decidedly of opinion that it is not necessary nor desirable to proceed with any general coating, painting, oiling, or washing of the whole building. It is quite obvious, in their judgment, that a very large proportion of the stone does not require any such application; but that what is wanted is some efficient process which should be applied to the surface of any stone that begins to show symptoms of decay, with a view to arrest its progress. The committee believe, that the persons to whom the care of the building is entrusted ought to watch it, and note, in the very earliest stages, wherever decay is perceptible, by efflorescence, change of color, crumbling, or slight decomposition.

20. In cases where the decay is important, and evidently occasioned

by the fall of rain on an upper projecting or exposed surface, protection should be afforded by a covering of sheet zinc or lead; and if, hereafter, any composition should fortunately be discovered, by which the decaying stone could be at once covered or coated, and the injurious influences of the atmosphere prevented from further acting upon it, the difficulty would be solved. In some extreme cases, the decayed stone might be cut out, and replaced with a new one. With regard to the processes which have actually been applied, whether experimentally or extensively, your committee are decidedly of opinion that the discovery of a proper mode of treating stones in a state of decay has not yet been made; and there is no evidence whatever on the building itself to induce them to believe that the decay, where decay has arisen, has been arrested, or that permanently the decay has been prevented, by any of the processes applied.

21. With reference to the second question, we found ourselves unable, after much labor, to come to any definite conclusion; and we finally requested the chemists in the committee to examine and report upon it; but those gentlemen state, as appears by their report in the Appendix, that the nature of the inquiry is so extensive, and that time is so important an element in the solution, that they are unable to give any opinion upon the subject. They further state, that they spent five whole days in the examination of only one suggested remedy; but they are unable, notwithstanding, to give any opinion on even that one suggestion. They allude to secret processes, regarding which they say they can offer no opinion; but they express a doubt of the applicability of any suggestion which would demand the veil of secresy for protection. Concurring in this view, it may be further noted that even if such applications were found successful in sample or experiment, no security would be afforded for a corresponding success in any subsequent large operations. They recommend that a series of experiments should be conducted, under chemical supervision, for a considerable period of time; and the committee are most reluctantly compelled to coincide with them, and to urge upon the government the adoption of such a course.

IV. The Qualities of the Stones to be recommended for future Use in Public Buildings to be erected in London.

22. On this head of the inquiry the committee have been unable, in the time allotted to them, to go into any very extensive examination. It is obvious, however, that although some varieties of magnesian limestone are an excellent and durable material, when not exposed to the deleterious influences of the London atmosphere; yet that in London it is subject to causes of decay, which render it an undesirable and unsafe material for the construction of public buildings.

23. It is equally obvious that Portland stone, well selected, has been used in buildings in London from the date of St. Paul's downwards, under circumstances of great exposure, and with most successful results. Portland stone is a material to be obtained in any quantity, and in blocks of any size, beautiful in color and texture, reason-

able in price, not by any means so hard as the Anston stone, and yet with a power of resisting the influences of the London atmosphere, that leaves but little to be desired. It must be remarked, however, that Portland stone should be carefully selected; an operation which would be the most satisfactorily effected by an agent at the quarries.

24. On this subject the commissioners could of course bring much personal experience to bear; but, after the valuable explanation of the principles upon which the decay of stone depends in populous places, as given by the chemists, in their report before referred to, the committee refrain from repeating those conclusions; in which, however, they entirely concur.

25. During the inquiries of the committee, one of their members, Mr. Burnell, who is well acquainted with architectural and engineering works in France, undertook, at his own expense, a journey to Paris, to inquire into the practice of the French architects engaged in the government works in that metropolis. There, the stone used, the "calcaire grossier," though a carbonate of lime of tertiary age, and therefore of very different mineral composition from our magnesian limestone of the much older Permian age, seems to suffer also from decay in a comparatively pure atmosphere, and where wood is chiefly used as fuel.

26. From the evidence of Mr. Burnell, it does not appear that French architects or chemists have been more successful than ourselves, either in the use of materials not subject to atmospheric influences, or in the application of processes for arresting decay when it has once begun. The opinions of the most scientific chemists and architects in France on this subject have, however, in this way been obtained; and it is extremely probable that the inquiries undertaken by them, simultaneously with those undertaken in this country, may hereafter lead to some successful result.

27. The committee have to thank the government for the facilities given to Mr. Burnell in this important part of the inquiry, by providing him with an introduction which obtained for him the active assistance of her Majesty's ambassador at the court of the Tuilleries.

28. The committee delegated, as before stated, to a sub-committee, the duty of examining the various buildings in London in which magnesian limestone from the Anston quarries had been introduced in the external architecture. The report of this sub-committee forms part of the Appendix; and we beg to refer to that report as confirmatory of our opinion of the uncertain character of magnesian limestone, and the risk attending the use of it in London.

29. In conclusion, the committee venture to recommend that the architect of the Palace of Westminster, assisted by scientific chemists, should examine and record the actual state of the stone work of the building at the present moment; that experiments should be made by their direction, under various conditions of height, exposure, and aspect, with such preservative materials and agents as the chemists may suggest from time to time; and that researches should be continued into the effects of the various alkaline silicates, the phosphates,

and other substances which have been brought under the notice of the committee, or suggested in Germany, France, or elsewhere; that where decay arises from damp, means should be taken to protect the stone, as has been before suggested; that any stone extensively decayed should be removed and replaced; but that in particular the earliest symptoms of decay should be carefully watched, and examined, with the view to the application of some immediate remedy. The committee believe that a very large portion of the stone in the Palace of Westminster is of a very durable nature; and they entertain a confident expectation that a remedy will soon be found to arrest or control the decay when it has unfortunately begun to appear.

William Tite,	M. Digby Wyatt,	George R. Burnell,
Rod. I. Murchison,	A. W. Hofmann,	Thomas Hawksley,
Sidney Smirke,	E. Frankland,	Charles H. Smith,
Geo. Gilbert Scott,	F. A. Abel,	Edward M. Barry.
George Godwin,	James Tennant,	

Alfred Bonham-Carter, Secretary.

Report of Sub-Committee of Chemists, referred to in the foregoing: and addressed to Chairman of the Committee.

17th June, 1861.

Sir:—We have the honor to inform you that we have complied with the wishes of the committee, by examining into the several proposals which have been laid before them for the preservation of the stone of the New Houses of Parliament; and that we have arrived at the following conclusions:—

1. Amongst the processes proposed, varying in principle and value to a very considerable extent, there is not one which we at present feel justified in proposing that the committee should definitely recommend as a preservative, either for general or local application.

2. A minute examination into one class of processes, submitted to the committee at an early period, has convinced us that, surrounded with great difficulties as the subject appeared at the outset, the obstacles eventually met with in an effective experimental inquiry are of a far more formidable character than could have been anticipated. Having devoted five days exclusively to the practical study of one of those processes (Ransome's), and having been unable in that period to elaborate even this single process sufficiently to warrant us in expressing a definite opinion upon its merits, it is obvious that anything like an elaborate examination of the numerous proposals which have only just now been submitted to us would require the expenditure of a far greater amount of time than the committee could place at our disposal.

3. Whilst regretting that it is not in our power to lay before the committee a positive recommendation of any particular process, we beg to submit the following observations:—

An examination into the nature of the several processes proposed, leads to their classification under two heads:—

(*a*) Processes which are likely to afford permanent protection to the stone.

(*b*) Processes which are only calculated to afford protection of a temporary character.

In both of these classes there are proposals which may at once be excluded from further consideration, on account either of their inapplicability to stones when placed in a building, or of the obvious misapprehension, on the part of the proposers, of the problem to be solved.

A proposal to protect stones by immersion in a boiling mixture of pitch, or resin, and oil, may be quoted in illustration of the processes which are only applicable to stones previous to their having become integral parts of any structure; again, the suggestion to cover the building with a coating of a mixture of silica with sulphur, applied in a semi-fluid condition, would involve almost insurmountable difficulties in its practical application; not to speak of the inflammability of the sulphur, which is only slightly diminished by the presence of the silica; or the uncertainty of the temporary character of the protection which, under the most favorable circumstances, could be afforded by this material.

Several of the suggestions are based upon notions so obviously erroneous, such as coating the building with sulphate of lead, and procuring an alleged galvanic protection by establishing connexions of this coating with plates of zinc; or, of ridding the building of the principle of decay by fermentation, that no object whatever could be gained by entering more fully into the merits of these proposals.

Of the processes which are intended to afford permanent protection to the stone, and the use of which is not precluded by the conditions of the case, there are several which claim a careful investigation. These processes may be classed under the following heads:—

1. Application of silicates of the alkalies, in various states of concentration.
2. Application of silicates, in conjunction with various saline compounds, intended to produce double decomposition.
3. Application of hydrofluoric or hydrofluo-silicic acid, or their saline compounds.
4. Application of phosphoric acid, and acid phosphates.
5. Application of solutions of the alkaline earths, or their bicarbonates, in water.

All these processes are more or less based upon chemical considerations, which are supported by analogy, and which, in the case of the two first-named classes, have received considerable experimental confirmation. The experiments which are now in progress with several of the processes included in the first two subdivisions, will, we believe, in the course of a few years, furnish ample data for correct conclusions regarding their applicability. In the meantime, it might be advisable to apply to portions of the New Houses of Parliament actually undergoing decay, certain processes selected as representatives of the remaining classes above enumerated, in order that their merits might be

submitted to the only conclusive tests,—those of actual application, and protracted exposure to the corrosive influence of a London atmosphere.

The second division of processes, namely, those which are only calculated to afford protection of a temporary character, are, from their very nature, of minor importance for the purposes of the committee's inquiry; nevertheless, as the claims to permanence of none of the processes of the first division have as yet been substantiated by the test of time, we would recommend that, in addition to the experiments already made in this direction, further trials be instituted of some of the more promising materials of this particular description. This recommendation is based upon the consideration that substances included under the appellation of organic, differ essentially in their powers of resisting the destructive action of the atmosphere. Whoever is acquainted with the nature of organic substances, cannot fail to appreciate the different degrees of stability under atmospheric influence exhibited by gluten, gelatine, or starch (which we find enumerated among the proposed protective agents), and by bees-wax and paraffine, not to speak of many of the fossil gums, which exhibit a degree of permanence approaching that of mineral substances.

The materials which we would recommend for selection to be tried in comparison with linseed oil, are paraffine, bees-wax, and some of the more permanent gums and resins, applied in the form of solutions in volatile solvents.

We should not omit to remark, that some of the witnesses and others who have addressed the committee, speak of secret processes. We cannot, of course, offer any opinion regarding such proposals; but we should doubt the applicability of any suggestion which would demand the veil of secresy for protection.

Finally, we beg to state, as the result of the experience which we have been enabled to acquire during the prosecution of our investigations on this subject, that a definite solution of the question at issue can only be arrived at after the lapse of a considerable period; since the relative merits of the processes which we recommend for trial can be established only by the test of time.

A. W. Hofmann,
E. Frankland,
F. A. Abel.

Report of Sub-Committee on Nature and Causes of Decay of Building Stones.

17th July, 1861.

Sir:—Having been requested to submit to the committee our opinion on the nature and causes of the decay of building stones generally, and of the stone employed in the construction of the New Houses of Parliament in particular, we now have the honor to submit the following observations:—

Building stones in general may be divided into two classes:—

1. Those which consist of materials not easily acted upon by acids.
2. Those composed of materials which are, partially or entirely, acted upon by acids with facility.

As an illustration of the first class, granite, porphyries, and serpentines may be quoted; whilst to the second belong limestones, dolomites, and certain sandstones, containing carbonate of lime as cementing material.

The stone used in the New Houses of Parliament belongs to the second class of building materials, consisting, as it does, almost entirely of the carbonates of lime and magnesia. The following analyses of several varieties of dolomite by Professor Daniell and Messrs. T. Ransome and B. Cooper, are quoted in illustration of the general composition of the stone in question:—*

	Bolsover Moor.		North Anston.		Woodhouse	Steetley.
	Daniell.	Ransome & Cooper.	Ransome & Cooper.	Ransome & Cooper.	Ransome & Cooper.	Ransome & Cooper.
				Stone ends		
Carbonate of lime, . .	51·1	52·07	54·89	55·37	52·80	53·95
Carbonate of magnesia, .	40·2	40·60	42·07	41·71	44·31	43·78
Sulphate of lime, . .						trace.
Protoxide of iron. . .		0·89	0·49	0·73	0·63	0·64
Oxide of iron and alumina, .	1·8					
Peroxide of iron, . .		0·83	0·24			
					Carbonate.	
Protoxide of manganese, .		trace.	trace.	1·68	1·84	
Silica, . . .	3·6	3·64	0·56	0·92	0·47	0·44
Water, . . .	3·3	0·48	0·51	0·45	0·23	0·12

	Roach Abbey.	Huddlestone.	Park Moor	Lindley's Bolsover Quarry. Woodhouse, near Mansfield.
	Daniell.	Daniell.	Daniell.	Ransome & Cooper.
Carbonate of lime, . .	57·5	54·19	55·7	54·05
Carbonate of magnesia, .	39·4	41·37	41·6	38·58
Protoxide of iron, . .				0·74
Peroxide of iron. . .				0·62
Oxide of iron and alumina, .	0·7	0·30	0·4	
Carbonate of manganese, .				2·43
Silica, . . .	0·8	2·53	0·0	1·30
Water, . . .	1·6	1·61	2·3	0·46

Regarded from a purely chemical point of view, the difference in the resisting power to corrosive agents of different stones, would appear, at first sight, to depend entirely upon their chemical composition; but even a moderate acquaintance with the properties of the components of such building stones, demonstrates that there are other conditions at least equally instrumental in determining the degree of permanence of different stones.

It is a well-established fact that *the same* chemical substance exhibits, in different conditions, a great variation in its behavior with chemical agents. Numerous examples might be quoted in illustration of this. Thus, marble and chalk are chemically identical; but, owing

* The analyses by Daniell are quoted from the "Report of the Inquiry undertaken under the Authority of the Lords Commissioners of Her Majesty's Treasury, by C. Barry, Esq., H. T. De la Beche, Esq., W. Smith, Esq., and Mr. Charles Smith, with reference to the selection of stones for building the New Houses of Parliament." Those by Ransome and Cooper are extracted from a paper on "The Composition of Limestones used for Building Purposes, especially on those employed in the Erection of the New Houses of Parliament," contained in vol. ii., part ii. (1848), of the Memoirs of the Museum of Practical Geology.

to the difference in their physical structure, the one being crystalline and the other amorphous, the former is much less readily acted upon by acids than the latter. Again, artificial peroxide of iron is readily soluble in acids; peroxide of iron, in the form of hæmatite, is attacked with difficulty by acids; and the same oxide, after exposure to a powerful heat, is almost entirely insoluble in acids. The influence of aggregation in these instances, and in numerous others which might be quoted, is obvious, and generally admitted by chemists, however different and imperfect may be their views regarding the connexion between physical condition and chemical effect.

The observations just made regarding the behavior of substances such as enter into the composition of building stones, cannot but apply with equal force to the aggregates of such components to the building stones themselves.

The atmospheric influences to which building stones are subject, are many of them essentially chemical actions, involving processes analogous to, or identical with, those performed in the laboratory; although, from the extreme dilution of the chemical agents, as existing in the atmosphere, they must necessarily be of a very gradual character.

There are few instances in which the influence of the state of aggregation upon the permanence of a building stone is more apparent than in that of the dolomitic limestone, used in the construction of the New Houses of Parliament. Here, in one and the same block of stone of comparatively small dimensions, we find certain portions of the surface powerfully disintegrated, while others appear in a perfectly sound condition. Chemical analysis has hitherto failed to establish any important difference in the composition of sound portions of such stones and those parts which are subject to decay: it is, therefore, legitimate to attribute the unequal permanence of the stone, under atmospheric influences, to such structural differences as may be comprehended under the term—state of aggregation.

Before proceeding to an examination of the particular charâcter of the decay observed in the stones of the New Houses of Parliament, it may perhaps be desirable to glance at the nature of the changes to which building stones generally are subject under atmospheric influences. Under normal conditions, these changes must be ascribed to the action of the oxygen, carbonic acid, nitric acid, and water, in the atmosphere. In the air of towns, however, there are certain other constituents, such as several acids of sulphur, and occasionally hydrochloric acid, which cannot fail to exert an additional disintegrating influence upon building stones.

The action of oxygen must be of comparatively a subordinate character; its effects being confined to constituents which occur but rarely, and generally in limited proportions, in building stones; such as the sulphides of iron, and the protoxides of iron and manganese; these compounds, being very prone to oxidation, would tend to disintegrate the stones by the absorption of oxygen. Of far greater importance are the effects of carbonic acid and water. Carbonic acid, in

the presence of water, is a powerful solvent: it not only corrodes the calcareous and magnesian carbonates (more or less powerfully according to their state of aggregation), whether they form the principal constituents of the stone, or are only present as cementing materials; but is capable even of attacking and gradually decomposing the hardest and most indestructible rocks.

In the case of the calcareous and magnesian constituents of stones, carbonic acid acts by transforming the insoluble earthy carbonates into soluble bi-carbonates, which are thus removed from the substance of the stone; whilst its influence on silicious rocks consists in the elimination of the alkaline bases, in the form of carbonates, and the separation of the silica in a more or less friable condition. The weathering of granites, and their gradual transformation into the several varieties of porcelain clay, afford an interesting illustration of the latter kind of action. In the changes just mentioned, the carbonic acid and water are equally concerned; the water serving not only as a vehicle for the introduction of the carbonic acid into the pores of the stone, but also as a solvent for the products of its action. There are changes, however, to which building stones are subject, in which water is the sole agent, and which are more of a mechanical than of a chemical character. The expansion which water undergoes on freezing, and the irresistible force which it then exerts, are well known: it is obvious that water freezing within the pores of a stone must exercise a disintegrating action not less powerful than those above referred to.

Recent researches have demonstrated that nitric acid is a frequent and perhaps even a normal constituent of the atmosphere, and, as such, must undoubtedly assist in the destruction of magnesian and calcareous stones; but the proportions in which this acid has been found are so minute, that it need not be dwelt upon as an important destructive agent. This remark, however, does not apply to the acids referred to above, as existing in the atmosphere of towns. The quantity of sulphur-acids in the air of towns where a considerable amount of coal is consumed, is quite appreciable. According to the determinations of Dr. Angus Smith, the air of Manchester contains an average proportion, corresponding to one part of sulphuric acid in every 100,000 parts of air, which, in the centre of the town, rises to twenty-five parts in 100,000. No numerical data exist with regard to the proportion of sulphur-acids in the London atmosphere; but it can scarcely be doubted that, in the neighborhood of the New Houses of Parliament, they are present to an extent equal to the average amount found in the Manchester air: they must, therefore, be regarded as among the more important agents, destructive to stone, which are present in the London atmosphere.

A few observations remain to be offered regarding the particular nature of the decay manifesting itself in some of the stone of the New Houses of Parliament. It has already been pointed out that, so far as our experience goes, we are inclined to attribute the local character of the decay to structural differences, obtaining in different parts of the stone. The general structure and the composition of the

stone in the New Houses of Parliament render it, moreover, amenable to all the sources of disintegration which we have above enumerated, with the exception, perhaps, of oxygen, which can scarcely produce any appreciable alteration in dolomite. Thus, the chemical action of carbonic and sulphuric acids, in combination with water, will gradually dissolve and remove the carbonates of lime and magnesia, whilst the porous nature of the stone renders it liable to the mechanical effects of water under the influence of frost. The presence of sulphuric acid in the air of towns appears, in the case of magnesian limestone, to bring into play another process of destruction. This acid not only corrodes and renders soluble, as we have pointed out, the earthy carbonates (in which respect it resembles carbonic acid in its effects), but, forming with magnesia a readily crystallizable salt, the well-known sulphate of magnesia, remarkable for the large proportion of water of crystallization which it fixes, it gives rise, in addition, to a mechanical destruction of the stone, precisely similar to that produced by freezing water. The powerful mechanical effects resulting from the solidification of water, induced by crystallization, are well known; although it would appear that they have not hitherto been sufficiently appreciated as auxiliaries in the process of disintegration of stone. The analogy between the solidification of water by freezing and by crystallization, is perfectly obvious; and a French chemist has suggested, as a means of recognising stones liable to disintegration by frost, to immerse them in a solution of sulphate of soda, and to note the subsequent effects of its crystallization within the stone.

We have ourselves recently had occasion to observe some phenomena which go far to elucidate these destructive effects of crystallization. The exfoliations exhibited by many of the fictile vases deposited in the British Museum were found to be due to the formation and crystallization, within the substance of the vessels, of nitrate of lime. Again, in experiments on the preservation of fabrics by impregnation with saline substances, it was found that the crystallization of sulphate of magnesia, within the material, produced a disintegrating effect upon the fibres, sufficient greatly to weaken the material.

In conclusion, we would remark, that the effect attributed to the crystallization of the sulphate of magnesia in assisting the decay of dolomitic stones, and more particularly of those used in the construction of the New Houses of Parliament, is borne out by the existence of a marked efflorescence of sulphate of magnesia upon those portions of the stone where exfoliation has taken place.

A. W. Hofmann,
E. Frankland,
F. A. Abel.

Railway Capital.—The annual return made to the Board of Trade shows that at the end of the year 1860, of the total capital raised by the railway companies of the United Kingdom, namely, £348,130,127, 54·8 per cent. had been raised by ordinary shares, 19·5 by preference shares, 2·2 by debenture stock, and 23·5 by loans, the respective amounts being £190,791,067, £67,873,840, £7,576,874, and £81,888,546.

Railway Stations.

Nouvelles Annales de la Construction.

A large portion of the September number of this periodical is taken up by illustrations of the railway stations erecting and about to be erected on the line of railway now in course of construction from Ancona to Bologna. These stations have already been referred to in the *Annales*, and now a report, pointing out the principle upon which they have been arranged, is furnished, illustrated by plans and other drawings, and worth the attention of those who have the arrangement of such buildings under their control.

Four classes of stations have been designed by Messrs. Oppermann for this line of railway, and we extract part of the descriptive report accompanying them, as useful in pointing out the way in which the exigencies of traffic should be taken into account, by the engineer and the architect, in laying down the first lines even of the plan of a railway station. It is almost needless to repeat the observation which we have already had occasion to make more than once, viz: that Continental railway management differs in so many details from English, that it is impossible for a Continental railway station ever to furnish a perfectly serviceable model for an English one. It would be well, however, if even only as much forethought, and as timely a recollection of simple and very obvious considerations, had been brought to bear upon some of our English stations, as is shown in the accompanying memorandum, and in the four simple plans which illustrate it.

"*Memorandum* —In the general arrangement of the buildings on the line from Ancona to Bologna, the attempt has been made, so far as practicable, to satisfy the following conditions :—

1. A separation of the passenger and goods departments: waiting rooms, refreshment rooms, conveniencies, and telegraph office being towards the right; baggage room, goods offices, and porters, &c., rooms on the left.

2. Making the distance which each traveler has to go over between the times of his entering and leaving the station, as short as possible.

3. Arranging the rooms in an order corresponding with the usual positions of 1st, 2d. and 3d class carriages (1st and 2d classes at the head of the train, and 3d class behind).

4. Avoiding any confusion of streams of travelers coming in with those going away, by arranging that the exit from the station shall not open upon the entrance lobby.

5. The above precaution is equally desirable in the case of baggage. In 1st class and 2d class stations, baggage is received through one door, and given out through a different one.

6. The station-master's office is in immediate contact with all the departments which he has to superintend (booking office, baggage office, postal and telegraph offices, &c.), and near the staircase which leads up to his dwelling.

7. The refreshment rooms are at one end of the station adjoining the waiting rooms, and the conveniences at the same end, detached.

8. In fact, a general correspondence has been established between the positions of the departments of the station, and the order of the carriages, &c., in the train (as standing opposite the platform). The lamp and oil room is opposite the engine, the baggage office opposite the baggage wagons, the 1st and 2d class waiting rooms near the head of the train, and the 3d class near its tail.

9. It is practicable to convert one class of stations into another, by the simple addition or suppression of bays or lengths; to facilitate this, the buildings are made to terminate at either end with a plain gable.

10. On the first floor all the rooms are separate, approached from one corridor lighted from its extremity, so that the rooms can be appropriated in any way desired. A kitchen and conveniences are placed at the head of the staircase."

The report, which gives some further details, also observes that it has been judged advantageous to place the refreshment rooms and the conveniences both at the same end of the station, and away from the other offices, as by this arrangement passengers actually in the train do not get confused among the passengers entering it; and the guard, should there be absentees at the moment when he requires to start, has only to go in one direction to look for them. The convenience is also very justly pointed out of having all the parts of each station, whatever its rank and consequent size, arranged in similar relation to each other; the traveler thus always knows beforehand, as if by instinct, in any station on the line, to what part he must go for any particular department.—*Civ. Eng. and Arch. Jour.*, Oct., 1861.

Railway Traveling.

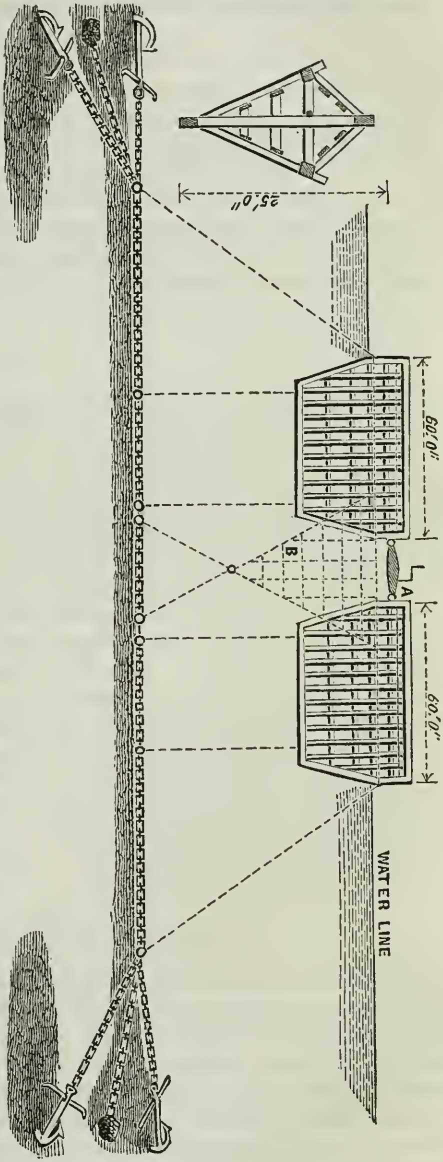
From the Lond. Mechanics' Mag., September, 1861.

The number of travelers by railway in the United Kingdom last year was 163,435,678, besides 47,894 holders of season and periodical tickets, who must have made very many journeys; in the whole there must have been much nearer six than five journeys in the year for every soul in the kingdom. The trains, passenger and goods trains together, traveled 102,243,692 miles, which is further than going 4000 times round the world; 267,134 horses and 357,474 dogs made railway journeys, little to their liking. The goods traffic comprised 12,083,503 cattle, sheep, and pigs, and 89,857,719 tons of minerals and general merchandise. In these vast piles of property conveyed from place to place, the minerals double the general merchandise in quantity, and they are carried at a little more than a quarter of the cost; 60,386,788 tons of minerals produced to the railway companies only £4,951,899, while 29,470,931 tons of general merchandise brought them £9,157,987. The receipts of the railways (10,433 miles in length at the close of the year) from all sources of traffic were £27,766,622, of which £13,085,756 came from passenger traffic and the mails, and the residue from goods. The expenditure was £13,187,368, or 47 per centum, leaving rather more than £14,500,000 net receipts. The compensation paid for accidents and losses amounted to £181,170. The quantity of rolling stock was no less than 5801 locomotives, 15,076 passenger engines, and 180,574 wagons for goods traffic, in all 201,451 engines and carriages. The numbers are enormous, and they are enormously increasing. Comparing last year with the year before, notwithstanding the bad weather, the passengers increased by 13,600,000, the minerals by 8,600,000 tons, the receipts by above £2,000,000, the miles traveled by trains by nearly 9,000,000. 3,896,960 trains ran in the course of the year 1860, upwards of 10,000 a-day, or more in a day than seven times the number of minutes in the day.—*Times.*

Admiral Tayler's Breakwater.

From the Lond. Engineer, No. 247.

SIR:—The formation of breakwaters and harbors of refuge, for the purpose of affording better shelter to our shipping upon our coasts, and of a less costly description, and better adapted for certain localities, than the system of solid masonry hitherto in use, and upon which millions of the public money is now being lavished, has been debated upon in Parliament, several inventions have been submitted to the government, and it is now recommended, by the select committee appointed to inquire into the practicability of such breakwaters and harbors, that £10,000 should be expended by government in testing any plans which may offer a probability of important results in future saving of money.



I beg to forward you a sketch of a plan for a floating breakwater, invented by Vice-Admiral J. N. Tayler, C. B., and which has been submitted recently to the government: and its adoption ultimately, I make no doubt, will be certain, from the fact of its capabilities having been already tested, and proved to be in every respect practically correct, and well adapted to the purpose intended, Admiral Tayler having devoted many years in bringing his invention to perfection.

This novel and much-approved plan consists of a number of sections of open timber framing, as per diagram, framed and bolted together, forming a structure prismatical in form; each section is 60 ft. in length 20 ft. beam, and floating 18 ft. below and 8 ft. above water mark. They are secured in position by means of ground moor-

ing chains and anchors, to which are attached bridle chains passing up through the keel to the horizontal chains, which are run through each section on both sides, forming one continual line of double chain through the entire length of the breakwater, and passing down at each extremity to the ground mooring. The sections are placed 20 feet apart, and the intervening space is filled up by netting chains, also secured to the ground mooring chain. The sections are further secured by means of iron couplings spanning the space between them, and so constructed as to allow of easy motion in the rise and fall of the sections by the action of the waves.

The principle of this invention consists in rendering the element itself the resisting barrier to the forces of the sea. This is a fact proved beyond dispute, for by the peculiar construction of the timber work, the water entering therein becomes inert and forms a barrier against itself, while the upper part of the section, being free, receives the upward wave, which, breaking on the seaward face, is quickly dispersed.

J. E. Reid.

Newington, September 7th, 1860.

Supplying Water to Locomotive Tenders without Stopping the Train.

From the London Artizan, December, 1860.

Mr. Ramsbottom, the Locomotive Superintendent of the Northern Division of the London and North-Western Railway, has recently patented a very ingenious method of economizing time in railway traveling. Instead of having to gradually slow and finally stop the train, for the purpose of refilling the tender with water—involving also further loss of time to regain the original speed—by Mr. Ramsbottom's plan the water is picked up, or made to flow into the tender whilst the train is running at full speed. The contrivance, which is of a highly philosophical character, is simple and not liable to derangement. We have recently witnessed experiments, which demonstrated the practicability of raising three-fourths of the water contained in a trough about a quarter of a mile in length, 16 to 18 inches wide, and 6 inches deep, whilst traveling at a speed of about forty to fifty miles an hour. By this means a saving of nearly half an hour may be effected in a run between London and Holyhead.

A New Slope-Level. By M. Ribot.

This instrument is designed to solve practically either of the following inverse problems, viz: to find the slope per metre of a given line; or, to set a line to a given slope per metre (or per yard). The instrument is so simple as scarcely to need description. The horizontal distance between the feet or points of support is exactly one metre (or yard). The right hand foot of the figure is capable of protrusion by a screw, and is provided with a scale to measure the amount of this protrusion. When the two feet are on a level, the index is at the zero of the scale. If you want to determine a given slope, project

the foot until the instrument stands on the slope, the protrusion measured on the scale gives the slope in terms of the distance apart of the feet (metres or yards). If you want to establish a given slope, set the foot to the indicated point of the scale, and adjust your plane to the instrument. The lower bar of the instrument may be graduated so that the plummet shall read angles of slope.—*Bull. Soc. d'Encour. pour l'Indus. Nationale.*

Experiments on the Effects of Vibratory Action and Long-continued Changes of Load upon Wrought Iron Bridges and Girders.

From the Lond. Athenæum, Sept., 1861.

W. Fairbairn, President of the Association, presented a paper containing a series of "Experiments on the Effects of Vibratory Action and Long-continued Changes of Load upon Wrought Iron Bridges and Girders."—He said this was a subject of great importance as affecting the construction of tubular and plate bridges, and also the lattice and trellis bridges. Fifteen years ago experiments were made which led to the construction of the Conway and Britannia tubular bridges on the Chester and Holyhead Railway, and determined the form in which such structures should be designed. Since that time some thousands of bridges had been built entirely of iron. The requirement of five tons per square inch on the part of the Board of Trade appeared to be founded on no fixed principle. It was well known that the power of resistance to strain of wrought iron depends very much upon the form in which it is combined, and unless the proportions of the parts were permanently established, the five-ton tensile strain might lead to error. For the purpose of making experiments upon the influence of vibration in causing the rupture of beams and bridges, he had constructed a small iron-plate beam of 20 feet clear span, and 16 feet deep, representing the proportion of one of the girders of the Spey Bridge, and exposed it to conditions similar to those of a bridge subject to changes of load as produced by the passage of trains, and in proportion to the heaviest rolling road. The beam was first loaded to one-fourth of its breaking weight, and it sustained a million changes of load without injury. The load was then increased to nearly one-half the breaking weight. With this weight the beam gave way after 5175 changes. It appeared, therefore, it was not safe to build bridges in which the rolling load would bear this proportion to the breaking weight. The beam was taken down and repaired, and the experiments were then renewed. The load was then reduced to two-fifths the breaking weight, and 25,900 changes of load were sustained. Lastly, the load was reduced to one-third, and the experiments were still proceeding, the beam being uninjured after 2,727,754 changes. In calculating the strain upon the area of the metal after deducting the rivet-holes, which, it must be remembered, were larger in proportion in this small beam than in bridges, he found that the beam would sustain no deterioration with strains of nearly $7\frac{1}{2}$ tons to

the square inch. With ten tons to the square inch, the beam broke after 5172 changes. Now, as the limit of elasticity was reached at about 9 tons per square inch in ordinary boiler plates and bridge plates, it would appear that it is unsafe to load structures subject to a continually varying load beyond that point. Within those limits, however, there was no evidence that a deterioration of structure took place. For the present, he would advise that in all beams and girders, tubular or plain, the permanent load or weight of the girder and its platform should not, in any case, exceed one-fourth of the breaking weight; and that the remaining three-fourths should be reserved to resist the rolling load in the proportion of six to one. He earnestly directed attention to the laws which governed the resisting powers of girders exposed to transverse strains, to the best principles of uniting the joints, and, above all, to the selection of the best material, which, in the parts of the girders subject to a tensile strain, ought always to sustain a test of from 22 to 24 tons per square inch. The use of superior metal for the bottom of the girders would give an increase of from one-fifth to one-sixth in the strength. There was no economy—and he wished particularly to impress this on the Section—in the use of inferior iron for this purpose, and its employment inevitably led to a loss of character in the structure and danger to the public.

Lord Wrottesley expressed his satisfaction that Mr. Fairbairn, with that public spirit which characterized him, was continuing those experiments which the Iron Committee, of whom he (Lord Wrottesley) was chairman, had commenced, but which they were not able to continue, through the discontinuance of the Government grant.

Mr. Fairbairn said he was glad to state that the Government had acted in a more liberal spirit to himself, and had granted £150 to conduct the experiments.

Proceedings of the British Association.

MECHANICS, PHYSICS, AND CHEMISTRY.

Abstract of an Investigation of the Resistance of Ships. By W. J. Macquorn Rankine, C. E., LL. D., F. R. S. S., London and Edinburgh.

From the London Artizan, Oct., 1861.

This paper is a very brief extract of the results of an investigation of the laws of the resistance of ships, founded originally on experimental data supplied to the author by Mr. James R. Napier, in 1857, and first applied to practice in order to fix beforehand the engine power required for a ship in 1858. To state all the mathematical details of the investigation would occupy much more time than can reasonably be allotted to one paper at a meeting of the British Association; the present communication, therefore, will be limited to a general view of the nature of the theory adopted, a statement of the practical rules to which it leads for computing the power required to propel a given ship at a given speed, an abstract of some comparisons between the results of that rule and those of experiment, a statement of some

limitations to the application of the theory, and some general conclusions deduced from it.

I. General View of the Theory.

The importance of friction as one of the elements of the resistance of water to the motion of a ship has long been recognised. Colonel Beaufoy made many experiments on models, expressly to ascertain its amount. Mr. Hawksley, some years ago, proposed a formula for the resistance of vessels, consisting of three terms, of which two, representing the effect of pressure on the bow and stern, depend on the area of midship section, and the figures of the bow and stern, while the third, representing the effect of friction, is proportional to the wetted surface of the ship. Mr. Bourne, in his work on the screw propeller, mentions friction as an element of the resistance of ships, which must depend on the girth rather than on the midship section.

It is to be remarked, however, that in all previous investigations as to the friction of ships in moving through the water, the velocity of the sliding motion of the particles of water over the ships bottom has been treated as being sensibly equal to the forward velocity of the ship, and sensibly the same at every point of the ships bottom; whereas, in fact, it must be different at different points of the ships bottom, at some points less than the ships speed, at other points greater; and on an average greater than the ships speed, in a proportion which is greater, the more bluff the figure of the ship. No definite results are to be expected from any comparison of experiment with a theory which does not take account of those variations.

It is further to be remarked that the excess of the pressure of the water against the bow of a ship above its pressure against the stern is only an indirect effect of friction; for were it not for the loss of motive energy which takes place through friction, the particles of water would close behind the vessel with such speed as to exert a forward pressure exactly equal to the backward pressure of the particles of water which are forced aside at the bow.

The author was induced by these considerations to investigate the theory of the friction of the water against the bottom of a ship, taking into account the various velocities of sliding at various points, as affected by the positions of those points and by the figure of the ship; and making only the following assumption: that the agitation in the water caused by the friction on the ships bottom extends only to a layer of water which is very thin as compared with the dimensions of the ship. This assumption enables the ratio which the velocity of sliding at any point bears to the speed of the ship to be expressed as a mathematical function of the position of the point, and of the ships figure, by the aid of the general equations of fluid motion; and from that function is deduced a certain integral which expresses the work performed in overcoming friction over the whole wetted surface of the ship, while the ship advances through a given distance, such as one foot; and to that quantity of work the force required to drive the ship against the friction of the water is proportional. The mathematical investigation is tedious and voluminous, and is reserved for a detailed paper.

The exact expressions arrived at were very complex, but were easily reduced to more simple expressions, giving an approximation sufficient for the purpose in view.

Upon comparing the formula thus obtained with the indicated power of actual ships moving at known speeds, it was found that *the whole* power required to propel the ships could be accounted for by friction alone, leaving none to be accounted for by any excess of pressure at the bow above that at the stern, except such excess as is indirectly caused by the friction, and virtually comprehended in the expression for the power required to overcome friction.

II. Practical Rule for the Power Required to Propel a Ship, with Trochoidal or nearly Trochoidal Water Lines, *i. e.* Wave Lines.

The first rule obtained in a form sufficiently simple for practical use was the following:—

"*The resistance of a sharp-ended ship exceeds the resistance of a current of water of the same velocity in a channel of the same length and mean girth, by a quantity proportional to the square of the greatest breadth, divided by the square of the length of the bow and stern.*"

The *mean girth* is found by taking the mean of the girths, as measured on the "body-plan" of the vessel, of the immersed part of a series of equidistant frames or cross-section.

The algebraical expression of this rule is as follows:—

$$\mathrm{R} = \frac{f\,w\,v^2}{2g} \cdot \mathrm{L\,G}\left(1 + \frac{\pi^2\,\mathrm{B}^2}{\mathrm{L}_1{}^2}\right) \quad . \quad . \quad . \quad (1.)$$

in which

R denotes the resistance of a vessel.

L her total length at the water-line, in feet.

L_1 the length of her bow and stern, in feet.

B her greatest breadth, in feet.

G her *mean girth* under water.

$\pi^2 = 9{\cdot}87$.

v the ships speed, in feet per second.

g the acceleration produced by gravity in a second, or 32·2 feet.

w the weight of a cubic foot of salt water, or about 64 lbs.

f a co-efficient of friction, whose value for iron ships in a clean state, as on their trial trips, is about ·0036, or nearly the same with the co-efficient of friction of water at high speeds in cast iron pipes.

The expression for the indicated horse power of the engine, deduced from the preceding formula, is as follows:—

$$\text{I. H. P.} = \frac{k\,\mathrm{R}\,v}{550} = \frac{k\,f\,w\,v^3}{550 \times 2g} \cdot \mathrm{L\,G}\left(1 + \frac{\pi^2\,\mathrm{B}^2}{\mathrm{L}^2{}_1}\right) \quad . \quad . \quad (2.)$$

In which k is a co-efficient expressing the ratio of the gross indicated power to the effective power, allowing for the friction of the machinery and slip of the propeller. Its average value is about 1·6; so that $k\,f =$ about ·00576 on an average for ships in a clean state.

But the most convenient formula for practice is one in which the velocity, V, is given in *nautical miles per hour*, and is as follows:—

$$\text{I. H. P.} = \frac{V^3}{C} \cdot L\,G\left(1 + \frac{\pi^2 B^2}{L^2{}_1}\right) \quad . \quad . \quad (3.)$$

C being a divisor, whose value is—

$$C = \frac{550 \times 2g}{4{\cdot}8064 \times k f w} = \frac{115}{k f} \text{ nearly} \quad . \quad (4.)$$

or if $k f = {\cdot}00576$, $C = 2000$ nearly.

This rule, with a co-efficient of resistance deduced from some experiments on previously existing vessels, was applied in 1858 to the computation of the engine-power required to propel a vessel then in course of construction (the *Admiral*); and at the trial trip of that vessel on the 11th of June, 1858, (the particulars of which, together with a copy of her body-plan, have been communicated to the Committee of the British Association on Steamship Performance,)* the actual engine-power was found to differ from the theoretically computed engine-power by less than one-fiftieth part of its amount, the computed power being 758, and the actual power 744, and that notwithstanding that the *Admiral* differed materially in her proportions from the vessels from whose performance the co-efficient of resistance had been deduced. The rule was afterwards applied with equal success to fix the required engine-power of other vessels built by Mr. J. R. Napier.

III. More Comprehensive Rule for the Power Required to Propel a Ship.

The rule in the form already given was deduced from a mathematical investigation based upon a trochoidal (or wave line) form of water-lines, and, therefore, although it could be applied with approximate accuracy to vessels approaching to that type, some doubt and difficulty arose in applying it to those which deviated widely from the trochoidal form. To obviate that difficulty, the rule was put into another form, which, while it was identical in its results with the original form for trochoidal water-lines, was more readily applicable to water-lines of other shapes. The alteration consists in this:—that instead of "*a quantity proportional to the square of the greatest breadth divided by the square of the length of the bow and stern, there is to be substituted a quantity proportional to the square of the chord of the mean angle of entrance of the water-lines,*" it being understood that the angle of entrance of a given water-line is the angle between its two tangents at opposite sides of the bow, at the points where it is *most inclined* to the keel; and that the mean value of that angle is to be taken for a series of equi-distant water-lines or horizontal sections of the vessel.

* See Report of that Committee to the Aberdeen Meeting of that Association, 1859.

The algebraical expression for the resistance now takes the following form:—

$$\text{R} = \frac{f\,w\,v^2}{2\,g} \cdot \text{L G} \left(1 + 4 \sin.^2 \frac{\theta}{2}\right) \quad . \quad . \quad (5.)$$

in which the symbols are the same with those already explained, except θ, which denotes the *mean angle of entrance* as already defined.

In what follows, for brevity's sake, the quantity $4 \sin.^2 \frac{\theta}{2}$ is denoted by b^2.

The two expressions for the engine-power become respectively

$$\text{I. H. P.} = \frac{k\,f\,w\,v^3}{550 \times 2g} \cdot \text{L G}\,(1 + b^2) \quad . \quad . \quad (6.)$$

$$= \frac{\dot{\text{V}}^3\,\text{L G}\,(1 + b^2)}{\text{C}} \quad . \quad . \quad . \quad (7.)$$

The processes involved in this rule may be represented to the mind as follows:—

1. Multiply together the length (L) of the vessel at the surface of the water, and the mean girth (G) of the immersed parts of the cross sections or frames; this gives the *area of the internal surface of a channel or tube of the same length and mean girth with the vessel* (L G).

2. Increase that area in the ratio of unity, plus the square of the chord of the mean angle of entrance $(1 + b^2)$ to unity; this increase is an approximate value of the allowance indicated by theory for the obliquity of the surface of the vessel, and for the excess of the speed of sliding of the particles of water over various portions of it, above the speed of the vessel. The result of this process (L G $(1 + b^2)$) may be called the "*augmented surface.*"

3. Compute the height from which a heavy body must fall to acquire the speed of the ship $\left(\frac{v^2}{2\,g}\right)$ multiply that height by a *co-efficient of friction* (f) deduced from experiment; conceive a layer of water of the thickness resulting from the last multiplication, to be spread over an area equal to the "*augmented surface;*" the weight of that layer will be the resistance of the vessel at the given speed (R).

4. Multiply that resistance by the speed of the vessel in feet per second, and by a factor (k) ascertained by experiment, to allow for the loss of power by slip and by the friction of the engine and propeller; the result will be the power or mechanical energy expended in a second, which, divided by 550, gives *indicated horse power.*

Although in most cases the co-efficient of friction (f) and factor for loss of power (k) cannot be separately ascertained, their product ($k\,f$) can always be ascertained by experiment, and this may be called the "*gross co-efficient of resistance.*"

5. The more convenient rule for finding the required indicated horse power may be thus expressed:—multiply the "*augmented sur-*

face" by the cube of the speed in knots, and divide by a divisor which is found by experiment.

$$\left(\text{C} = \frac{115}{k\,f}\right)$$

IV. Comparison of the Theory with the Experiment.

In applying this theory to experimental data, the proper course is to compute from those data the value in each case either of the *gross co-efficient of resistance* $(k\,f)$, or of the *divisor* (C), which is inversely proportioned to that co-efficient; and should those values present such variations only as can be accounted for by ordinary variations in the efficiency of engines and propellers, and in the condition of the vessel's bottom, the inference is in favor of the soundness of the theory. It is necessary in every case to have access to the plans of the vessel, and hence complete sets of data are less abundant than could be wished. The formulæ to be employed are as follows:—

For the divisor,

$$\text{C} = \frac{\text{V}^3\,\text{L}\,\text{G}\,(1 + b^2)}{\text{I. H. P.}} \quad . \quad . \quad . \qquad (8.)$$

For the gross co-efficient of resistance,

$$k\,f = \frac{115}{\text{C}} \quad . \quad . \quad . \quad . \quad . \qquad (9.)$$

The following table gives nine examples of such calculations. Three of them are founded on experiments made by Mr. J. R. Napier and the author, on published data relative to Government vessels, and two are published reports of trial trips of vessels belonging to the Peninsular and Oriental Steam Navigation Company.

Example.	Length.	Breadth.	Mean draft.	Midship section.	Displacement.	Mean girth.			Augmented surface.	Speed knots.		Divisor.	Co-efficient of gross resistance.
	L.					G.	L. G.	$1 + b^2$.	L. G $(1+b^2)$	V.	I.H.P	C.	$k.f.$
	ft.	ft.	feet.	sq. ft.	tons.	feet.	sq. ft.		sq. ft.				
I. Vulcan (paddle),	160	16	4·5	56	140	14 75	2360	1·1	2596	14·5	412	19210	·00599
II. Black Swan. now Ganges (s.)	244	36·5	13·8	385	1670	40	9760	1·2	11712	12	970	20864	·00551
III. Admiral (paddle),	210	32	7·5	214	820	31·5	6615	1·36	9000	11·9	744	20385	·00565
IV. Rattler (screw),	178	33	11·25	274	870	32·5	5785	1·4	8099	10·07	428	19360	·00593
V. Rattler (screw),	178	33	13·50	330	1078	37·5	6675	1·4	9345	9·64	437	19370	·00593
VI. Fairy (screw),	140	21·1	4·83	71·5	168	19·0	2660	1·2	3192	13·33	364	20770	·00554
VII. Fairy (screw),	140	21·1	5·83	82	196	21·5	3010	1·23	3702	11·9	321	19435	·00592
VIII. Ceylon (screw),	290	41	18·5	649	3000*	52·4	15196	1·16	17625	13·34	2054	20371	·00565
IX. Nubia (screw),	280	39 5	17·25	515	2100*	48·2	13496	1·16	15655	12·15	1422	19725	·00583
					*Nearly.								

The breadth, mean draft of water, midship section, and displacement, are given in each case, to show the variety of forms and sizes to which the calculations relate. The displacement ranges from 140 to 3000 tons; the proportion of length to breadth, from $5\frac{1}{2}$ to 10; the proportion of breadth to draft of water, from $2\frac{1}{2}$ to $4\frac{1}{2}$.

The final results show the *divisor* as ranging from 19210 to 20864, and the *gross co-efficient of resistance*, from ·00599 to ·00551.

V. Limitations to the Theory.

The theory stated in this paper is not applicable to vessels which are so bluff at the bow and stern as to push before them or drag behind them a mass of water full of whirling eddies; for in such vessels the assumption already stated, that the water agitated by friction is a very thin layer, is not fulfilled.

Neither is the theory applicable to a vessel which raises a wave that buries a considerable portion of her bows. This does not occur in well-shaped vessels of the sizes to which the experiments already quoted relate; but it may occur in models, as experiments made by Mr. J. R. Napier and the author have shown. Small wooden models of vessels were made, of very various proportions, the proportion of length to breadth ranging from *five* to *ten*. The *proportionate* resistance of these models when dragged in pairs at equal speeds were tested by means of suitable apparatus, and it was found that when the speed was so small as not to raise a wave exceeding the ordinary proportion of the height of the wave to the dimensions of the vessel in large ships (say from $\frac{1}{10}$th to $\frac{1}{20}$th of the draft of water), the results of the experiments exactly agreed with the theory; but when the speed was increased until the wave buried from one-half to the whole of the bows of the models, the resistance of the broader model was increased in a greater proportion than that of the narrower.

From the result of these experiments it follows that, in order that conclusions drawn from experiments on models may be applicable to actual ships, care should be taken not to move the model at a speed which raises a wave exceeding in proportionate height the wave raised by the large vessel; and, that such may be the case, the velocities of the model and of the ship should be proportional to the square roots of their linear dimensions. For example, the models already mentioned were about $\frac{1}{100}$th part of the linear dimensions of the vessel that they were intended to represent; and when dragged at $\frac{1}{10}$th of the speed of those vessels, or less, their resistance followed the same laws, but not otherwise. This conclusion is common to the theory of the present paper, and to Mr. Scott Russell's wave theory.

The effect of such waves as have been here referred to on the resistance might be taken into account by means of a supplementary theory, provided a sufficient number of experiments had been made on the large scale to determine the necessary data; but in the experiments on the large scale quoted in this paper, the resistance due to the wave at the bow seems to have been insensible, or to have been balanced, or nearly balanced, by the pressure of the wave at the stern. This balanced action is to be expected in vessels whose lengths, as prescribed by Mr. Scott Russell, are equal, or nearly equal, to the lengths of waves traveling with the same speed.

VI. Deductions from the Theory.

The approximate expression for the resistance may be divided into two terms, one of which is increased, and the other diminished, by increase of length. For a vessel of a given size and type there is some

proportion of length to breadth which makes the resistance a minimum. To determine that proportion exactly by the method of maxima and minima would be a process of extreme complexity and difficulty; but from a series of approximate calculations made by way of trial, it would appear to be not very far from that of 7 to 1—a conclusion in accordance with that which some authorities on ship-building have deduced from practical experience. It appears further, that of two vessels which deviate equally in opposite directions from the best proportion, the larger has less resistance than the shorter; this conclusion also agrees with practical experience.

If, as the comparison of the theory with experiment seems to show, the resistance of a vessel is proportional to what has been called the *augmented surface*, it is the area so designated, and not the midship section, which should regulate the areas of paddles and screws.

The results of the investigation described in the paper tend to prove that friction constitutes the most important part, if not the whole, of the resistance of ships that are well shaped for speed, and that its amount can be deduced with great precision from the figure of the ship by the aid of proper mathematical processes. On this, as well as other accounts, it is to be desired that the data which are collected by the Committee of the British Association on Steam Ship Performance should be accompanied as far as possible by drawings of the ships lines; at all events, by the "body plans," from which the forms of water-lines can easily be constructed when the distances between the frames are known.

Prevention of Rotting of Wood.

To prevent posts and piles from rotting, the following coating has been recommended, which is the more suitable since it is economical, impermeable to water, and nearly as hard as stone.

Take 50 parts of rosin, 40 of finely-powdered chalk, 300 parts (or less) of fine white sharp sand, 4 parts of linseed oil, 1 part of native red oxide of copper, and 1 part of sulphuric acid. First heat the rosin, chalk, sand, and oil, in an iron boiler; then add the oxide, and with care, the acid: stir the composition carefully, and apply the coat while it is still hot. If it be not liquid enough, add a little more oil. This coating, when it is cold and dry, forms a varnish which is as hard as stone.—*Dingler's Polytech. Jour.—Bull. Soc. d'Encour. pour l'Indus. Nation.*

Growing of Plants by Electric Light.

At the meeting of the Academy of Sciences of Paris, of August 5th, 1861, M. Hervé Mangon presented the details of an experiment in which he had grown the seeds of rye under the influence of electric light alone. The plants assumed their green tint rapidly and vigorously, and showed no perceptible difference from those grown in ordinary day light.

Table of the Properties of Saturated Steam. Calculated by L. O.

From the Lond. Artizan, Sept., 1861.

In examining the existing tables of the properties of steam, we find that very few of them are correct, some because they are calculated from formulæ, based upon bygone and inaccurate experiments, and some because they are calculated from formulæ for steam in a gaseous state, which of course will not apply to saturated steam, generally used in practice. Having long felt the want for more correct tables for the properties of *saturated* steam, the Author has thought that the accompanying table, calculated by him, according to the newest and the best authorities upon steam, might be considered useful. In respect to the columns three and four, the Author is indebted to Mr. D. K. Clark for the use of his formulæ.

Atmosphere included.		Temperature of steam.	Specific volume.	Number of atmospheres.	Atmosphere excluded.	
Pounds per sq. inch.	Inches of mercury.				Inches of mercury.	Pounds per sq. inch.
lbs.	Inches.	Fahr.	Sp. vol.	Atmos.	Inches.	lbs.
1	2·0355	102·1	20582	·068	—27·886	—13·7
2	4·0710	126·3	10721	·136	—25·851	—12·7
3	6·1065	141·6	7322	·204	—23 815	—11·7
4	8·142	153·1	5583	·272	—21·780	—10 7
5	10·178	162·3	4527	·340	—19 744	— 9·7
6	12·213	170·2	3813	·408	—17·709	— 8·7
7	14·249	176·9	3298	·476	—15·673	— 7·7
8	16·284	182·9	2909	·544	—13·638	— 6·7
9	18·320	188·3	2604	·612	—11·602	— 5·7
10	20·355	193·3	2358	·680	— 9·567	— 4·7
11	22·391	197·8	2157	·748	— 7·531	— 3·7
12	24·426	202·0	1986	·816	— 5·496	— 2·7
13	26·462	205·9	1842	·884	— 3·460	— 1·7
14	28·497	209·6	1720	·952	— 1·425	— 0·7
14·706	29·922	212·0	1642	1·000	∓ 0·000	∓ 0·0
15	30·533	213·1	1610	1·020	0·611	0·3
16	32·568	216·3	1515	1·088	2·646	1·3
17	34·604	219·6	1431	1·156	4·682	2·3
18	36·639	222·4	1357	1·224	6·717	3·3
19	38·675	225·3	1290	1·292	8·753	4 3
20	40·710	228·0	1229	1·360	10·788	5·3
21	42 746	230·6	1174	1·428	12·824	6 3
22	44·781	233·1	1123	1·496	14·859	7·3
23	46·817	235 5	1075	1·564	16 895	8·3
24	48·852	237 8	1036	1·632	18·930	9·3
25	50·888	240·1	996	1 700	20·966	10·3
26	52·923	242·3	958	1·768	23·001	11·3
27	54·959	244·4	926	1·836	25·037	12·3
28	56·994	246·4	895	1·904	27·072	13·3
29	59·030	248·4	866	1·972	29·108	14·3
30	61·065	250·4	838	2·040	31·143	15·3
31	63·101	252·2	813	2·108	33·179	16·3
32	65·136	254·1	789	2·176	35·214	17·3

TABLE (CONTINUED).

Atmosphere included.		Temperature of steam.	Specific volume.	Number of atmospheres.	Atmosphere excluded.	
Pounds per sq. inch.	Inches of mercury.				Inches of mercury.	Pounds per sq. inch.
lbs.	Inches.	Fahr.	Sp. vol.	Atmos.	Inches.	lbs.
33	67·172	255·9	767	2·244	37·250	18·3
34	69·207	257·6	746	2·312	39·285	19·3
35	71·243	259·3	726	2·380	41·321	20·3
36	73·278	260·9	707	2·448	43·356	21·3
37	75·314	262·6	688	2·516	45·392	22·3
38	77·349	264·2	671	2·584	47·427	23·3
39	79·385	265·8	655	2·652	49·463	24·3
40	81·420	267·3	640	2·720	51·498	25·3
41	83·456	268·7	625	2·788	53·534	26·3
42	85·491	270·2	611	2·856	55·569	27·3
43	87·527	271·6	598	2·924	57·605	28·3
44	89·562	273·0	585	2·992	59·640	29·3
45	91·598	274·4	572	3·060	61·676	30·3
46	93·633	275·8	561	3·128	63·711	31·3
47	95·669	277·1	550	3·196	65·747	32·3
48	97·704	278·4	539	3·264	67·782	33·3
49	99·740	279·7	529	3·332	69·818	34·3
50	101·776	281·0	518	3·400	71·854	35·3
51	103·811	282·3	509	3·468	73·889	36·3
52	105·847	283·5	500	3·536	75·925	37·3
53	107·882	284·7	491	3·604	77·960	38·3
54	109·918	285·9	482	3·672	79·996	39·3
55	111·953	287·1	474	3·740	82·031	40·3
56	113·989	288·2	466	3·808	84·067	41·3
57	116·024	289·3	458	3·876	86·102	42·3
58	118·060	290·4	451	3·944	88·138	43·3
59	120·095	291·6	444	4·012	90·173	44·3
60	122·131	292·7	437	4·080	92·209	45·3
61	124·166	293·8	430	4·148	94·244	46·3
62	126·202	294·8	424	4·216	96·280	47·3
63	128·237	295·9	417	4·284	98·315	48·3
64	130·273	296·9	411	4·352	100·351	49·3
65	132·308	298·0	405	4·420	102·386	50·3
66	134·344	299·0	399	4·488	104·422	51·3
67	136·379	300·0	393	4·556	106·457	52·3
68	138·415	300·9	388	4·624	108·493	53·3
69	140·450	301·9	383	4·692	110·528	54·3
70	142·486	302·9	378	4·760	112·563	55·3
71	144·521	303·9	373	4·828	114·599	56·3
72	146·557	304·8	368	4·896	116·635	57·3
73	148·592	305·7	363	4·964	118·670	58·3
74	150·628	306·6	359	5·032	120·706	59·3
75	152·663	307·5	353	5·100	122·741	60·3
76	154·699	308·4	349	5·168	124·777	61·3
77	156·734	309·3	345	5·236	126·812	62·3
78	158·770	310·2	341	5·304	128·848	63·3
79	160·805	311·1	337	5·372	130·883	64·3
80	162·841	312·0	333	5·440	132·919	65·3
81	164·876	312·8	329	5·508	134·954	66·3

TABLE (CONTINUED).

Atmosphere included.		Temperature of steam.	Specific volume.	Number of atmospheres.	Atmosphere excluded.	
Pounds per sq. inch.	Inches of mercury.				Inches of mercury.	Pounds per sq. inch.
lbs.	Inches.	Fahr.	Sp. vol.	Atmos.	Inches.	lbs.
82	166 912	313 6	325	5·576	136 990	67·3
83	168·947	314·5	321	5·644	139·025	68·3
84	170·983	315·3	318	5·712	141·061	69·3
85	173·018	316·1	314	5·780	143 096	70·3
86	175·054	316·9	311	5·848	145·132	71·3
87	177·089	317·8	308	5·916	147·167	72·3
88	179·125	318 6	305	5·984	149·203	73·3
89	181·160	319·4	301	6·052	151·238	74·3
90	183·196	320·2	298	6·120	153·274	75·3
91	185·231	321·0	295	6·188	155·309	76·3
92	187·267	321·7	292	6·256	157·345	77 3
93	189·302	322·5	289	6·324	159·380	78·3
94	191·338	323·3	286	6·392	161·416	79 3
95	193·373	321·1	283	6·460	163·451	80 3
96	195·409	324·8	281	6·528	165·487	81·3
97	197·444	325 6	278	6·596	167·522	82·3
98	199·480	326·3	275	6·664	169·558	83·3
99	201·515	327·1	272	6·732	171·593	84·3
100	203·551	327·9	270	6·800	173·629	85·3
101	205 587	328·5	267	6 868	175·665	86·3
102	207·622	329·1	265	6·936	177·700	87·3
103	209·658	329·9	262	7·004	179·736	88·3
104	211·693	330·6	260	7 072	181·771	89·3
105	213·729	331·3	257	7·140	183 807	90·3
106	215·764	331·9	255	7·208	185·842	91·3
107	217·800	332·6	253	7·276	187 878	92·3
108	219 835	333·3	251	7·344	189·913	93.3
109	221·871	334·0	249	7·412	191·949	94·3
110	223·906	334·6	247	7·480	193·984	95·3
111	225·942	335·3	245	7·548	196·020	96·3
112	227·977	336·0	243	7 616	198·055	97·3
113	230·013	336·7	241	7·648	200·091	98·3
114	232·048	337 4	239	7·752	202·126	99·3
115	234·084	338·0	237	7 820	204·162	100·3
116	236·119	338 6	235	7·888	206·197	101·3
117	238·115	339·3	233	7·956	208·233	102·3
118	240·190	339 9	231	8·024	210·268	103·3
119	242·226	340 5	229	8·092	212 304	104·3
120	244·261	341·1	227	8·160	214·339	105·3
121	246·297	341·8	225	8·228	216·375	106·3
122	248·332	342·4	224	8·296	218·410	107·3
123	250·368	343·0	222	8·364	220 446	108·3
124	252·403	343·6	221	8·432	222·481	109·3
125	254·439	344·2	219	8·500	224·517	110·3
126	256·474	344·8	217	8·568	226·552	111·3
127	258·510	345·4	215	8 636	228 588	112·3
128	260·545	346·0	214	8·704	230·623	113·3
129	262 581	346·6	212	8·772	232·659	114·3
130	264·616	347·2	211	8 840	234·694	115·3

TABLE (CONCLUDED).

Atmosphere included.		Temperature of steam.	Specific volume.	Number of atmospheres.	Atmosphere excluded.	
Pounds per sq. inch.	Inches of mercury.				Inches of mercury.	Pounds per sq. inch.
lbs.	Inches.	Fahr.	Sp. vol.	Atmos.	Inches.	lbs.
131	266 652	347·8	209	8·908	236·730	116·3
132	268·687	348·3	208	8·976	238·765	117·3
133	270·723	348·9	206	9·044	240·800	118·3
134	272·758	349·5	205	9·112	242·836	119·3
135	274·794	350·1	203	9·180	244·872	120·3
136	276·829	350·6	202	9·248	246 907	121·3
137	278·865	351·2	200	9·316	248·942	122·3
138	280·900	351·8	199	9·384	250·978	123·3
139	282·936	352·4	198	9·452	253·014	124 3
140	284·971	352 9	197	9 520	255 049	125·3
141	287·007	353·5	195	9·588	257·085	126 3
142	289 042	354·0	194	9·656	259·120	127·3
143	291·789	354·5	193	9·724	261·156	128 3
144	293·113	355·0	192	9·792	263·191	129·3
145	295·149	355·6	190	9·860	265·227	130·3
146	297·184	356·1	189	9·928	267 262	131·3
147	299·220	356·7	188	9·996	269·298	132·3
148	301·255	357·2	187	10·064	271 333	133·3
149	303·291	357·8	186	10·132	273·369	134·3
150	305·327	358·3	184	10·200	275·405	135·3
155	315·504	361·0	179	10·540	285·582	140·3
160	325·682	363·4	174	10·880	295·760	145·3
165	335·859	366·0	169	11·220	305·937	150·3
170	346·037	368·2	164	11·560	316·115	155·3
175	356·214	370·8	159	11·900	326·292	160·3
180	366·392	372·9	155	12·240	336·470	165·3
185	376·569	375·3	151	12·580	346·647	170·3
190	386·747	377·5	148	12·920	356·825	175·3
195	396·924	379·7	144	13·260	367·002	180·3
200	407·102	381·7	141	13·600	377·180	185·3
210	427·457	386·0	135	14·280	397 535	195·3
220	447·812	389·9	129	14·960	417 890	205·3
230	468 167	393·8	123	15·640	438·245	215·3
240	488·522	397·5	119	16·320	458·600	225·3
250	508 878	401·1	114	17·000	478·956	235·3
260	529·233	404·5	110	17·680	499·311	245·3
270	549·587	407·9	106	18·360	519·666	255·3
280	569·943	411·2	102	19·040	540·021	265·3
290	590·297	414·4	99	19·720	560·376	275·3
300	610·653	417·5	96	20·400	580·731	285·3
350	712·429	430·1	83	23·800	682·507	335·3
400	814 204	444·9	73	27·200	784·282	385·3
450	915·980	456·7	66	30·600	886·058	435·3
500	1017·755	467·5	59	34·000	987·833	485·3
600	1221·306	487·0	50	40·800	1191·384	585·3
700	1424·857	504·1	43	47·600	1394·935	685·3
800	1628·408	519·5	38	54·400	1598·486	785·3
900	1831·959	533·6	34	61·200	1802 037	885·3
1000	2035·510	546 5	31	68 000	2005·588	985·3

The Boiling-points of Different Liquids.

From the London Chemical News, No. 83.

The laws relating to the boiling-points of different liquids at the ordinary pressure of the atmosphere have lately been investigated by Mr. Tate, and the results of his experiments are published in the *Philosophical Magazine.* He has made experiments with solutions containing the chlorides of sodium, potassium, barium, calcium, and strontium; the nitrates of soda, potassa, lime, and ammonia; and the carbonates of soda and potassa. He has found for all these salts that the augmentation of boiling temperature may be approximately expressed in a certain power of the per centage of the salt dissolved. The salts enumerated may be divided into four distinct groups; namely, first, the chlorides of sodium, potassium, and barium, and the carbonate of soda; second, the chlorides of calcium and strontium; third, the nitrates of soda, potassa, and ammonia; fourth, the carbonates of potassa and nitrate of lime. In each of these four groups, the augmentations of boiling temperature of the solutions have a constant ratio to one another for an equal weight of salt dissolved. He has also ascertained by experiments that for an equal weight of salts, the boiling temperatures are (approximately) in the inverse ratio of the chemical equivalents of their bases, and in the case of the nitrate of lime and the carbonate of potassa with the equivalents of the entire salts. Although the law thus indicated is not strictly true, it is sufficiently exact to warrant further inquiry, and the cases in which it is found to apply are too numerous to be referred to accidental coincidence. Future researches may extend these laws to other substances, as it is quite consistent with analogy to suppose that the chemical composition of a substance affects the boiling temperature of its solution. It will readily be acknowledged that the prosecution of these experiments may throw additional light upon the generation of steam, the economy of fuel, and kindred questions of great practical importance to engineers.

For the Journal of the Franklin Institute.

On the Economy of Using Steam Expansively. By H. P. M. Birkinbine, Chief Engineer of the Philadelphia Water Works.

The economy of using steam expansively has been much before the public of late, and many conflicting statements have been published, evidently produced by the Report of the Erie Experiments made by the United States Naval Engineers, in which the conclusions were contrary to the usually admitted experience of engineers.

A rough experiment made with one of the pumping engines of the Water Works of this city, may not be uninteresting. This engine was originally so arranged as to carry steam the entire length of the stroke; the valve gear was much worn, and defective in its arrangement; a new valve gear was put upon the engine, by which the steam could be cut off at any point of the stroke. The experiments to test

the value of this improvement were not made with the precision and care they should have been for publication, but were made simply for the use and information of the department. The results may, however, be taken as practically correct, although more carefully conducted experiments might make a slight difference.

The experiments were commenced immediately after cleaning the fires and coaling, and terminated when the fires required the final cleaning and coaling; the time being 28 and 28½ hours, with but a slight interval between the experiments, simply to alter the position of the cams which opened the valves. In firing, the usual practice of the department was observed, viz: keeping a clean fire, coaling frequently, clinkering and thoroughly cleaning the fires about once in twelve hours. The coal used was anthracite (Lehigh white ash) of fair quality. The load upon the engine and the condition of the engine pump and boilers were the same in both experiments. In the first experiments, and with the old valve gear, it required careful firing to keep the engine in motion at any thing like a fair speed, say twelve revolutions per minute. In the experiment with steam cut off at half stroke, as the engine is now running, it is kept up with ease. Steam was not cut off at less than half stroke, on account of the boilers, which are old, and not considered perfectly safe at over 60 pounds pressure. It will be seen that this engine is not economical in fuel, nor is it constructed on the most approved plan, but these experiments show the economy of using steam expansively, in this instance at least.

Description of Engine.—The engine upon which the experiments were made is a non-condensing one, included within the operations of the Philadelphia Water Department, and forms part of the machinery for supplying the inhabitants of what was formerly the District of Kensington with water. It has a horizontal steam cylinder, 30 inches in diameter, and works a double-acting pump, 18 inches in diameter, each piston having a stroke of six feet. The pump is placed horizontally about 25 feet in front of the steam cylinder, and in a plane 18 feet below it. The piston-rod of the cylinder gives motion to the upper end of the vibrating beam, by means of a cross-head and a short connecting rod, while a similar cross-head and rod transmit the motion of the lower end of the beam to the piston-rod of the pump. From the upper end of the beam a connecting-rod also gives motion to a crank-shaft and fly-wheel, by means of which the motion of the engine is equalized. The pump receives its water from the river under a head of about four feet at mean tide, and forces it through an 18-inch pipe 13,260 feet long to a reservoir 118 feet above the average level of the river.

The steam and exhaust valves of the cylinder are of the "Cornish equilibrium" variety, placed in chests at each end of the cylinder, and are operated by cams on a revolving shaft driven by bevel-wheels from the crank-shaft of the engine.

The arrangement for varying the "cut-off" is simple and effective. Each steam valve is opened by a roller on the end of an appropriate

lever, which is depressed by a raised face or projection on a corresponding cam. The cams are so made that by moving them longitudinally on the shaft, faces of greater or less length, corresponding to different grades of expansion, are presented to the roller on the end of the valve lever.

Steam is generated in six cylindrical boilers, set in brick-work. Under each boiler, in the chamber behind the bridge-walls, is a supplementary boiler or heater, connected to the main boiler by wrought iron pipes.

PRINCIPAL DIMENSIONS OF ENGINE AND BOILERS.

Diameter of cylinder of engine,	30 ins.
Length of stroke of piston of engine,	6 ft.
Cubical contents of nozzle and clearance at each end of cylinder,	1·5 cub. ft.
Diameter of pump cylinder,	18 ins.
Stroke of piston of do.	6 ft.
Diameter of fly-wheel,	22 ft.
Weight of rim of do.,	13,000 lbs.

Boilers.—Six cylindrical boilers set in brick-work. To the under side of each boiler is connected a cylindrical heater or drum.

Diameter of Boilers,	40 ins.
Length of do.,	26 ft.
Diameter of heaters,	30 ins.
Length of do.,	16½ ft.
Total heating surface, including one-half of the whole surface of boilers and the whole of the surface of heaters, about	1500 sq. ft.
Area of grate surface,	200 "

OBSERVED RESULTS OF EXPERIMENTS.	Without Expansion.	With Expansion.
Duration of experiments,	28·5	28
Total number of revolutions,	21,860	26,250
Total pounds of coal consumed,	21,520	16,270
Pressure of steam as per gauge on boilers,	38	50
Average effective pressure per square inch of steam piston as per indicator diagram,	28·5	28·5
DEDUCTIONS FROM OBSERVED RESULTS.		
Revolutions per minute,	12·78	15·62
Revolutions per pound of coal,	1·015	1·613
Coal per horse power per hour,	8·073	5·083
Coal consumed per hour per square foot of grate,	3·75	2·9
Coal consumed per revolution, in pounds,	·984	·619
Water evaporated per pound of coal, in pounds,	6·72	5 85
Coal saving with expansion in per centums of coal used without expansion,		37·03

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By WM. BRYSON, Civ. Eng.

(Continued from vol. xlii., page 405.)

In the *Builder*, vol. v, page, 18,—Jan. 9th, 1847,—the following "Question as to the Strength of Cast Iron," was published:—

"Suppose I wish to settle the scantlings of some iron castings, such as girders, pillars, &c., and suppose that, with the intention of resting my case upon the best and soundest authority, I consult Tredgold's well-known Essay on Cast Iron, in which I find some beautiful theories of the action of forces upon materials, joined to what the author seems to have considered sufficiently sound data for the strength of the particular material, cast iron. But, suppose my copy of the book is one of the fourth edition (edited by Mr. E. Hodgkinson, 1842), in which I find in the editor's notes some slur cast upon Tredgold's accuracy, principally as regards the varying strength of iron of different manufactures, of which many sorts are said to be very much below the author's assumed average:—

"Now, I wish to ascertain whether, if my girders, &c., are procured from manufacturers of established credit and respectability, in London or elsewhere, they may not be calculated to possess the degree of strength, at elastic limits, which is assumed in Tredgold's formulæ? If not, what may be expected to happen to the numerous buildings in which cast iron supports have been used, but which have been erected previously to the recent researches of Mr. Hodgkinson and Mr. Fairbairn? I have not yet procured a detailed copy of these: when I do, shall I have to unlearn Tredgold's beautiful system of calculating pillars and struts, or shall I only be obliged to modify his constants to suit another scale of strength?"

Weisbach says, "In 1817, Barlow's Essay on the 'Strength of Timber, Iron, and other materials,' was published, and English engineers were thus put far on the way of making 'principles of science rules of their art.' A few years afterwards, Tredgold's Essay 'On the Strength of Cast Iron and other Metals,' was published; and this remarkable work of a most remarkable man, together with Barlow's work, had, all engineers will admit, a powerful influence in extending the rational use of iron in construction. Ten years later, Mr. Eaton Hodgkinson of Manchester, began a course of inquiry on the strength of iron, which, while it has earned for him and his coadjutor, Mr. Fairbairn, a high reputation for scientific knowledge and skill, has, even more directly than the earlier works mentioned, contributed to the present important position of iron as a material in construction."

Mr. Fairbairn in his report on the Construction of Fire-proof Warehouses, says that Mr. Hodgkinson is "one of the first authorities in this or any other country on the strength of materials. To that gen-

tleman the public are indebted for a series of theoretical and practical experiments on the strength of beams and pillars, of the utmost value to architects, builders, and engineers. Any person choosing to make himself acquainted with the principles of Mr. Hodgkinson's experiments and the results deduced therefrom, will find no difficulty in constructing beams and columns of the strongest form, and at the same time insuring the proportional and requisite strength, accompanied with a great saving in material in all parts of the structure."

Mr. Hodgkinson in his "Experimental Researches," remarks that "The acknowledged want of practical information upon this subject (the strength of pillars), and its great importance, made me anxious to undertake an extensive series of experiments upon it, such as would confirm or show the error of existing theories, and give such information as would be of real service to the engineer and architect, whilst they tended to unfold the laws that regulate the strength of pillars. This wish was, as on other occasions, cheerfully responded to by my friend William Fairbairn, Esq., at whose expense the extensive series of experiments was made."

Extracts from Mr. Hodgkinson's Experimental Researches:—

"In all long pillars of the same dimensions, the resistance to fracture by flexure is about three times greater when the ends of the pillar are flat and firmly bedded, than when they are rounded and capable of turning."

"The strength of a pillar, with one end round and the other flat, is the arithmetical mean between that of a pillar of the same dimensions with both ends rounded, and with both ends flat. Thus, of three cylindrical pillars, all of the same length and diameter, the first having its ends rounded, the second with one end rounded and one flat, and the third with both ends flat, the strengths are as 1, 2, 3, nearly."

"A long uniform pillar, with its ends firmly fixed, whether by discs or otherwise, has the same power to resist breaking as a pillar of the same diameter, and half the length, with the ends rounded or turned so that the force would pass through the axis."

"The preceding properties were found to exist in long pillars of steel, wrought iron, and wood."

"A pillar irregularly fixed, so that the pressure would be in the direction of the diagonal, is reduced to one-third of its strength, the case being nearly similar to that of a pillar with rounded ends, the strength of which has been shown to be only one-third of that of a pillar with flat ends."

Note.—"Tredgold, art. 283 of his work on Cast Iron, and in his Treatise on Carpentry, following the idea of Serlio in his Architecture, recommends circular abutting joints to lessen the effect of irregularity in the strains upon columns, from settlements and other causes; but this, we see, is voluntarily throwing away two-thirds of the full strength of the material to prevent what may often be avoided."

Mr. Tredgold remarks, "The writer of the article 'Bridge,' in the Supplement to the *Encycl. Brit.*, has shown that, when the force acts in the direction of the diagonal of the block (or column), the strain will be twice as great as when the same force acts in the direction of the axis. Now, the reader will be satisfied that, in consequence of settlements or other causes, a column is always liable to be strained in this manner, and therefore will carefully avoid enlarging the ends of his columns under the notion of gaining stability, for the effect of the straining force will be still more increased by such enlargement in the event of a change of direction from settlement. In my 'Treatise on Carpentry,'" Mr. T. says, "I have recommended circular abutting joints to lessen the effect of a partial change in the position of the strained pieces: an idea which appears to have occurred, in the first instance, to Serlio."

Mr. Fairbairn, in treating "On the Construction of Fire-proof Warehouses," says, "The base of the lower column should in every case be considerably enlarged, and the ends faced in the lathe; the base-plate which receives it should also be faced. This is the more necessary, as it gives an even surface for the purpose of leveling the plate and maintaining the vertical position of the column. The same operation is performed on the upper end of the socket, and on the bottom of each succeeding column."

In Tredgold's Essay on the Strength of Cast Iron, the following formula is given for the strength of a solid cylindrical column of cast iron to resist compression in the direction of its length, when the force acts in the direction of one of the surfaces of the column; d representing the diameter in inches, l the length in feet, and W the weight to be supported in lbs.,

$$\frac{9562\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{W}.$$

And in this *Journal*, vol. xli, page 248, Mr. Haswell gives a similar formula for the safe weight of a solid cylindrical column of cast iron, thus,

$$\frac{10{,}000\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{W}.$$

Mr. Tredgold remarks of his table calculated from the above formula, that it "shows by inspection the weight or pressure a cylindrical pillar or column of cast iron will bear with safety. The pressure is expressed in cwts., and is computed on the supposition that the pillar is under the most unfavorable circumstances for resisting the stress, which happens when, from settlements, imperfect fitting, or other causes, the direction of the stress is in the surface of the pillar." An abstract of this table, and also of Mr. Haswell's, is given further on.

Mr. Tredgold gives the following example of the use of his table.

"If it be desired to fix on the diameter for story posts of cast iron to support the front of a house; such a one, for example, as is commonly erected in London, where the ground story is to be occupied with shops. In such a case, each foot in length of frontage may be estimated at 25 cwts. for each floor, and 12 cwts. for the roof; hence in a house with three stories over the shops, the extreme load will be

$$(3 \times 25) + 12 = 87 \text{ cwts.},$$

on each foot of frontage. Now, if the posts be 7 feet apart, and 12 feet high, we have $7 \times 87 = 609$ cwts., the load upon one post; and hence we find by the table, that a pillar $6\frac{1}{2}$ inches in diameter would be sufficient; the load 525 cwts., which corresponds to a diameter of 6 inches, being too small.

"If there be only two stories above the pillars, and the height of a pillar be 10 feet, the distance from pillar to pillar 7 feet; then

$$\overline{(2 \times 25) + 12} \times 7 = 434 \text{ cwts.},$$

the whole load for one pillar; and it appears by the table, that a pillar 5 inches in diameter would sustain 452 cwts.; consequently, 5 inches will be a proper diameter for the pillars.

"When pillars are placed at irregular distances, that which carries the greatest load should be calculated for; and if it happen that such a pillar stands 10 feet from the next support on one side, and 6 feet from the next support on the other side, add these distances together, and take the mean for the distance apart; thus,

$$\frac{10 + 6}{2} = \frac{16}{2} = 8,$$

the mean distance of the supports.

"The strain upon a pillar cannot be exactly in the direction of the axis when the pillars are placed at unequal distances to support an uniform load; and since this unequal distribution of supports is extremely common in story posts, the propriety of adopting the mode of calculation I have followed is evident."

Abstract from Mr. Tredgold's table, entitled

"A Table to show the Weight or Pressure a Cylindrical Pillar or Column of Cast Iron will sustain with Safety, in Hundredweights."

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.
5	501	479	452	427	394	365	337	310
6	592	573	550	525	497	469	440	413
7	1013	989	959	924	887	848	808	765
8	1315	1289	1259	1224	1185	1142	1097	1052
9	1697	1672	1640	1603	1561	1515	1467	1416

Table showing the calculated weight from Mr. Tredgold's formula, in hundredweights and tons,

$$\frac{9562\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{w}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
5	501·11	478·47	452·19	423·75	394·42	365·26	337 02	310·22
6	735·28	711·45	683·00	651·16	617·16	582·09	546·88	512·25
7	1012·36	987·78	957·87	923 68	886 30	846 75	806·00	764·86
8	1332·26	1307·16	1276·25	1240·40	1200 54	1157·62	1112·54	1066·14
9	1694·93	1669·48	1637·84	1600·77	1559·07	1513·57	1465 11	1414·51
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
5	25·05	23·92	22 60	21·18	19·72	18·26	16·85	15·51
6	36·76	35·57	34·15	32·55	30·85	29·10	27·34	25 61
7	50·61	49·38	47·89	46·18	44·31	42 33	40 30	38·24
8	66·61	65·35	63·81	62 02	60·02	57·88	55·62	53·20
9	84·74	83 47	81·89	80·03	77 95	75 67	73·25	70·72

Abstract from Mr. Haswell's table, entitled

"*Table showing the Weight or Pressure a Column of Cast Iron will Sustain with Safety.*"

	Length or height in Feet.							
	6	8	10	12	14	16	18	20
Inch.								
5	58,617	56,043	52,884	49,959	46,098	42,705	39,439	36,270
6	69,264	67,041	64,350	61,425	58,149	54,873	51,480	48,321
7	118,521	115,713	112,203	108,108	103,779	99,216	94,536	89,505
8	153,855	150,813	147,303	143,208	138,645	133,614	128,349	123,084
9	198,549	195,624	191,880	187,551	182,637	177,255	171,639	165,672

Table showing the calculated weight from Mr. Haswell's formula, in pounds and tons,

$$\frac{10{,}000\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{w}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5	58,696	56,043	52,966	49,634	46,200	42,784	39,477	36,337
6	86,124	83,333	80,000	76.271	72,289	68,181	64,056	60,000
7	118,579	115,699	112.196	108,192	103,813	99.182	94,408	89,589
8	156,049	153,110	149,489	145,289	140,620	135,593	130,313	124,878
9	198,529	195,547	191,842	187,500	182,615	177,285	171,610	165,681
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
5	26·20	25·01	23·64	22·15	20·62	19·10	17·62	16·22
6	38·44	37·20	35 71	34 04	32·27	30 43	28 59	26·78
7	52·93	51·65	50·08	48·30	46·34	44·27	42·14	39·99
8	69·66	68·35	66·73	64·86	62·77	60 53	58·17	55·74
9	88·62	87·29	85·64	83·69	81·52	79·14	76·61	73·96

Tables from my calculations, being one-tenth and one-fourth of the breaking weight as deduced from Mr. Hodgkinson's formulæ for solid pillars of cast iron with both ends flat and firmly fixed.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
TABLE SHOWING ONE-TENTH OF THE BREAKING WEIGHT, IN TONS.								
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
5	45·07	33 75	25·97	19·57	15·06	12·00	9·82	8·21
6	74 67	57·85	45·60	36·66	28·77	22·93	18·77	15·69
7	112·68	89·87	72·39	63·91	49 06	39·63	32·44	27·12
8	159·15	130·11	106·86	88·63	70 59	63·13	52 12	43·57
9	214·07	178 75	149·36	125·59	106·53	91·23	78·86	66·19
TABLE SHOWING ONE-FOURTH OF THE BREAKING WEIGHT, IN TONS.								
5	112·68	84·39	64·94	48·94	37·66	30·01	24·56	20·53
6	186·69	144·64	114·01	91·66	71·94	57·33	46·92	39·23
7	281·71	224·68	180·98	159·79	122·65	99·09	81·11	67·81
8	397·89	325·29	267·16	221·58	176·47	157·84	130·30	108·93
9	535·19	446·88	373·40	313·98	266·34	228·08	197·16	165·49

Table showing One-Fourth of the Calculated Breaking Weight, in Tons,

As deduced from Mr. Hodgkinson's formulæ for cast iron pillars with rounded ends, as will be seen by referring to a table comparing the strength of pillars, further on.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
5	70·10	46 13	31·56	23·15	17·81	14·19	11 62	9·71
6	126·42	90·26	62·65	45·95	35·36	28·18	23·05	19·28
7	202·65	149·04	111·86	82·05	63·13	50·31	41·18	34·42
8	300·58	227·22	175·99	135·56	104·31	83·12	68·04	56 88
9	420·74	326·09	257 11	206·77	162·42	129·44	105·95	88·57

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44 \cdot 16 \frac{D^{3 \cdot 55}}{L^{1 \cdot 7}}$.	Calculated breaking weight in tons from formulæ, $W = 44 \cdot 16 \frac{D^{3 \cdot 55}}{L^{1 \cdot 7}}$. $Y = \frac{W c}{W + \frac{3}{4} c}$.
6	10 2-7	7	722·37		1126·87
8	13 5-7	"	963·16		898·74
10	17 1-7	"	1203·95		723 93
12	20 4-7	"	1444·74		639·16
14	24	"	1685·53		490·63
16	27 3-7	"	1926·32	396·38	
18	30 6-7	"	2167·11	324·46	
20	34 2-7	"	2407·90	271·24	
6	9	8	943·50		1591·59
8	12	"	1258·00		1301·19
10	15	"	1572·50		1068·65
12	18	"	1887·01		886·34
14	21	"	2201·51		705·91
16	24	"	2516·01		631·38
18	27	"	2830·51	521 23	
20	30	"	3145·01	435·74	
6	8	9	1194·12		2140·76
8	10 2-3	"	1592·16		1787·55
10	13 1-3	"	1990·20		1493·63
12	16	"	2388·24		1255·95
14	18 2-3	"	2786·28		1065·36
16	21 1-3	"	3184·32		912·33
18	24	"	3582·36		788·67
20	26 2-3	"	3980·40	661·96	

Solid Cylindrical Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formula, $W = 6{\cdot}71 \frac{D^4}{L^2}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{Wc}{W + \frac{3}{4}c}$.
8	13 5-7	7	2·138	100·86		251·72	132·80	95·15
9	15 3-7	"	2·405	113·46		198·89	"	88·48
10	17 1-7	"	2 672	126·07		161·10	"	82 06
11	18 6-7	"	2 939	138·68		133·14	"	75·96
12	20 4-7	"	3·207	151·29		111·87	"	70·25
13	22 2-7	"	3·474	163·89		95·32	"	64·94
14	24	"	3·741	176 50		82·19	"	60·04
15	25 5-7	"	4·008	189 10		71·60	"	55·54
16	27 3-7	"	4·276	201·72		62·93	"	51·41
17	29 1-7	"	4·543	214·32		55·74	"	47·65
18	30 6-7	"	4 810	226 93		49·72	"	44·21
19	32 4-7	"	5·077	239·54		44·62	"	41·08
20	34 2-7	"	5·345	252·15		40·27	"	38·23
21	36	"	5·612	264·75		36·53	"	35·63
22	37 6-7	"	5·879	277·36		33·28	"	33·25
23	39 3-7	"	6·146	289·97	30·45			
24	41 1-7	"	6·414	302·58	27·96			
25	42 6-7	"	6·681	315·18	25·77			
26	44 4-7	"	6·948	327·79	23·83			
27	46 2-7	"	7·215	340·40	22·09			
28	48	"	7·483	353 01	20·54			
29	49 5-7	"	7·750	365·61	19·15			
30	51 3-7	"	8 017	378 22	17·90			

Solid Cylindrical Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 4{\cdot}79 \frac{D^4}{L^2}$.			
8	13 5-7	7	2·138	93·10		179·69	113·14	76·85
9	15 3-7	"	2·405	104·73		141·98	"	70 81
10	17 1-7	"	2·672	116·37		115·00	"	65·10
11	18 6-7	"	2·939	128 01		95 04	"	59·77
12	20 4-7	"	3·207	139·65		79·86	"	54 85
13	22 2-7	"	3·474	151·29		68 05	"	50·35
14	24	"	3·741	162·92		58·67	"	46·11
15	25 5-7	"	4·008	174·56		51·11	"	42·53
16	27 3-7	"	4·276	186·20		44 92	"	39·16
17	29 1-7	"	4·543	197·84		39·79	"	36·11
18	30 6-7	"	4·810	209·47		35·49	"	33·36
19	32 4-7	"	5 077	221·11		31·85	"	30·87
20	34 2-7	"	5·345	232·75		28·75	"	28·63
21	36	"	5·612	244·39	26 07			
22	37 6-7	"	5·879	256·02	23·76			
23	39 3-7	"	6·146	267·66	21·74			
24	41 1-7	"	6·414	279·30	19·96			
25	42 6-7	"	6 681	290 94	18·40			
26	44 4-7	"	6·948	302·58	17·01			
27	46 2-7	"	7·215	314·21	15·77			
28	48	"	7·483	325·85	14·66			
29	49 5-7	"	7·750	337·49	13·67			
30	51 3-7	"	8·017	349·13	12·77			

(To be Continued.)

PROCEEDINGS OF THE BRITISH ASSOCIATION.

From the London Athenæum, Sept., 1861.

Section G.—*Mechanical Science.*

Mr. D. Chadwick, Secretary of the Manchester Cotton Supply Association, read a paper, "On Recent Improvements in Cotton Gins." A description was given of the old Indian churka, one of which was exhibited to the meeting, and the invention of the American saw gin, by Eli Whitney, was also noticed and described. On the recent visit of Dr. Forbes, the superintendent of the cotton gin factory of the late East India Company, to Darwhar, he introduced an improved cotton gin, based upon the principle of the Indian churka. This churka gin had subsequently been improved by Mr. John Dunlop, of Manchester, and Messrs. Platt Brothers, of Oldham, and the improved machines were exhibited to the meeting. The improvements in Messrs. Platt's machines consisted in the application of spike rollers revolving at different speeds in connexion with vibrating machinery, which transmits the cotton to the ordinary churka rollers. The effect of this is to enable the machine to be supplied with cotton at intervals instead of continuously with the fingers. The machine is intended to be worked by power, and requires the attendance only of a child thirteen years of age. Mr. Dunlop's machine was less expensive, more compact, bearing a closer resemblance to the original churka, and was intended to be worked by hand.

Mr. T. Bazley, M. P., said the machines before them were wonderful improvements on the old churka. He noticed the destruction of fibre and the waste occasioned by the American saw gins, and said he had seen cotton in the market selling for 7d. per ℔., which, if cleaned by a roller gin, would have sold for 2s. per ℔. The injuries inflicted upon the raw cotton were not so great as upon the long fibre cotton, because the teeth of the saws allowed the short fibres to go through without severing them. During the last few years, an improved kind of roller gin, known as the Macarthey Gin, had been introduced into America. An intimate friend of his had obtained one of these gins, and placed it in the hands of Mr. Dunlop, who had made a large number of these gins, which the Cotton Supply Association had forwarded to the various cotton-producing districts of the world. But when he turned to the machine which had been constructed by Mr. Platt, that appeared so him to be the machine best adapted for the cleaning of a very large quantity of cotton in a short time without injury to the fibre. He was very glad to see these machines in the room, though he feared they would soon be in the position of the cook who had all the appliances for cooking a good dinner, but was without the mutton and the beef to cook. He was afraid, unless very serious efforts were made, this great industry of theirs would be very much depressed.

Mr. Ashworth said he believed the Indian cotton, which, as now cleaned, was worth 4d. per ℔., would be worth 5d. per ℔., if cleaned by the cotton gins exhibited.

Mr. J. F. Bateman, President of the Section, made a communication, "On Street Pipe Arrangements for Extinguishing Fires." He had hoped that a paper would have been read on this subject by Mr. Rose, of the Manchester Fire Brigade, but as that gentleman had been called away by the illness of a relative, he (Mr. Bateman) thought it right that the proceedings of the Section should not terminate without some observations being made on the subject. Nothing could have been much worse than the arrangements made for the extinction of fires some fifteen years ago, and nothing could be much worse than the state of things which existed at the present day in the City of London. In most large towns, as Manchester and Glasgow, for instance, where the supply of water had been taken into the hands of the Corporation, the best preparations had been made for the extinction of fires. But in London, the fire engines and the brigade were maintained by contributions from the different insurance companies, and it was therefore evident that their interest only lay in preventing the destruction of property that was insured. It was clear this was a state of things which ought not to exist in this country. Some twelve or fifteen years ago he turned his attention to the subject of the extinction of fires. The old wooden plug or fire-cock was then generally in use, and it still continued in use in some parts of the country. Mr. Bateman described the construction of the branch stand-pipe, with which he had replaced the old plugs in Manchester and other towns, and stated that as a general rule these stand-pipes had been found sufficient without the use of fire engines. He also explained the principle upon which the water-pipes were laid down in Manchester; so that within reach of nearly every block of valuable buildings in Manchester and the neighborhood, there were from two to three sources of water supply, and ten or twelve fire-cocks within a hundred yards. Then came the question of pressure. It was popularly supposed that water could be thrown to any height; but this was not so. About eighty or ninety feet was the greatest height water could be thrown by a fire engine. The highest mills in Manchester were from forty feet to sixty feet, and experiments had been made to show that at the low pressure the stand-pipes would throw ninety feet.

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Mr. C. W. Siemens explained a system of telegraphic communication adopted in Berlin in the case of fires, by means of which, immediately after a fire occurred, the police at every station in the town could be informed of the occurrence, and of the district in which the fire had occurred. He said it was found by the adoption of this system that the fire engine was generally on the ground five minutes after the alarm had been given. He also explained and exhibited a system of railway signalling extensively adopted on the Continent, which rendered collisions almost impossible.

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Col. Sir H. James, R. E., described the process of "Photozincography," by means of which photographic copies of the Ordnance maps are cheaply multiplied, either on their original or on a reduced

or enlarged scale. The process is applicable to the reproduction of old manuscripts and old printed books. A copy of Domesday Book (the part relating to Cornwall taken by this means) was exhibited to the meeting. The process consists in taking a photographic collodion negative, which is intensified by means of bichloride of mercury and sulphate of ammonia. Paper deprived of its size is saturated with a solution of gelatine and bichromate of potash. The paper thus prepared is exposed to the light beneath the negative, the result of which is that the parts which have been exposed to the light become hardened and insoluble. The whole is then inked with a greasy ink, and afterwards washed in water, which removes the ink from all the parts except those on which the light has acted. A transfer to stone or zinc is then taken in the ordinary way, and copies are printed. Sir Henry James then described an improvement which had lately been made in the process, by means of which a reduced copy of a map or plan could be made, in which the minor detail (which would be useless on a reduced scale) could be omitted, and the names of places and other features of the plan given in full-sized legible characters.

Mr. Haworth read a paper explaining his patent for Improvements in Street Railways, by the addition of a fifth or perambulator wheel to the carriages, running as a guide in a central groove between the trams. It was calculated that a saving of 35 per cent. would be effected by this plan.

Mr. Vignoles expressed his opinion that if any street railway were ever adopted, Mr. Haworth's system would be the one. He had never seen a more promising system.

Appalling Boiler Catastrophe.

From the Lond. Artizan, Oct. 1861.

The vicinity of Rotherhithe, near the Commercial Docks, was, on the evening of the 16th ult., the scene of a most frightful catastrophe, occasioned by the explosion of a steam boiler at the Lower Ordnance Wharf, in the occupation of Messrs. Francois and Joseph Badart, oil cake manufacturers, by which no fewer than ten persons lost their lives. The premises occupy a large area on that portion of the waterside which is known as Cuckold's Point, opposite to the Limehouse entrance of the West India Docks, and about half a mile from the Commercial Dock-pier. They comprised several buildings, wherein the processes of grinding the seed, extracting and refining the oil, and compressing the oil cakes, were carried on. The machinery, which was very extensive, was propelled by steam power. The boiler and engine-house stood on the river side of the mills, parallel with the wharf, and contained two long boilers, of 50 horse-power each, laid in massive brick-work. The number of hands generally employed in the mills is somewhat limited, considering their extensive character, but owing to the pressure of business and the urgency of some shipping orders, a relay of workmen was taken on on Monday evening at

six o'clock, for night work. Only one boiler had been at work during the day; and it appears that about the same time the night men came on, six o'clock, a defect was noticed in a joint of the feed pipe to the engine. The engine-driver at once sent for an engine-fitter, at the same time turning the steam off the boiler. It would seem, however, that the driver, acting under the impression, probably, that the joint would speedily be repaired, had omitted to draw the furnace, as a quantity of fire is stated to have been in it. The fitter arrived, and, with the driver, proceeded down to the engine-room and commenced their work, but finding that they required assistance, they communicated with one of the officials, and the whole of the laborers who had just come on were sent to their aid. Six of the men were desired to support the pipe which runs across the roof, while the engine-fitter went on with repairing the joint. There had been three or four other laborers in the chamber, but, their services not being immediately required, they had only left a few minutes before the explosion took place. The men had not been long at work at the joint before those in other parts of the factory were alarmed by a loud rumbling noise and heavy concussion, which shook the neighborhood, followed by a terrific crash, and a rush of steam and smoke. The boiler-house was seen to be in ruins, and at the time it was difficult to say what would be the fate of the whole property. It was some minutes ere any attempt could be made to approach the engine-room, where the unhappy men had been at work. At length, the smoke and steam having somewhat subsided, two of the men who had only left the place a minute or so before, and two or three other laborers, contrived to make a descent to where the poor creatures were imprisoned, and the sight which presented itself was truly horrible. The engine-room was a small brick chamber, about 8 ft. by 12 ft., at the basement of the mills. A glance at the boiler clearly showed that some portion of it had exploded, and had sprung forward from its bed of brick-work four or five feet, and that the inner part of the boiler, with the massive iron bars of the furnace and other plates, had been blown out, as if from a cannon's mouth, direct at the poor fellows who were at work only some four or five feet in front. Of the ten unhappy creatures who were in this chamber, not one escaped. Two or three were dashed against the brick wall and killed on the spot, their skulls being driven in by the iron bars and pieces of boiler which were scattered by the explosion. Others were frightfully burnt and scalded, and bleeding from fearful gashes on their heads and other parts of their bodies. The boiler was a Cornish one, and had not been in use any length of time. It is stated that the pressure at which it had been worked during the day was from 40 lbs. to 50 lbs. the square inch, considerably below that at which it had been worked, while it had been tested to a pressure equal to 100 lbs. The safety-valve, and the other gear which would have assisted in arriving at the true pressure, appear to have been carried away, and it is feared that there will be some difficulty in eliciting the truth, as all those who could have given the information have fallen victims.

For the Journal of the Franklin Institute.

A JAPANESE AND ENGLISH CALENDAR,

Arranged for the year 1858–59, *by* S. MISIMA, *a Japanese, one of the Government Interpreters at Nagasaki.*

ALMANAC (Japanese and English) in the Year 5th Ansai (1858).

1.		2.		3.		4.		5.		6.		7.		8.		9.		10.		11.		12.	
Sio-gooath.		Ni-gooath.		San-gooath.		Si-gooath.		Go-gooath.		Rock-gooath.		Hechu-gooath.		Hachu-gooath.		Koo-gooath.		Ju-gooath.		Juits-gooath.		Juni-gooath.	
Jap.	Eng.	Jap.	Eng.	Jap.	Eng.	Jap.	Eng.	Jap.	Eng.	Jap.	Eng.	Jap.	Eng.	Jap.	Eng.	Jap.	Eng	Jap.	Eng.	Jap.	Eng.	Jap.	Eng.
1	14 February.	1	15	1	14	1	13	1	11	1	11	1	9	1	7	1	7	1	6	1	5	1	4
2	15	2	16	2	15	2	14	2	12	2	12	2	10	2	8	2	8	2	7	2	6	2	5
3	16	3	17	3	16	3	15	3	13	3	13	3	11	3	9	3	9	3	8	3	7	3	6
4	17	4	18	4	17	4	16	4	14	4	14	4	12	4	10	4	10	4	9	4	8	4	7
5	18	5	19	5	18	5	17	5	15	5	15	5	13	5	11	5	11	5	10	5	9	5	8
6	19	6	20	6	19	6	18	6	16	6	16	6	14	6	12	6	12	6	11	6	10	6	9
7	20	7	21	7	20	7	19	7	17	7	17	7	15	7	13	7	13	7	12	7	11	7	10
8	21	8	22	8	21	8	20	8	18	8	18	8	16	8	14	8	14	8	13	8	12	8	11
9	22	9	23	9	22	9	21	9	19	9	19	9	17	9	15	9	15	9	14	9	13	9	12
10	23	10	24	10	23	10	22	10	20	10	20	10	18	10	16	10	16	10	15	10	14	10	13
11	24	11	25	11	24	11	23	11	21	11	21	11	19	11	17	11	17	11	16	11	15	11	14
12	25	12	26	12	25	12	24	12	22	12	22	12	20	12	18	12	18	12	17	12	16	12	15
13	26	13	27	13	26	13	25	13	23	13	23	13	21	13	19	13	19	13	18	13	17	13	16
14	27	14	28	14	27	14	26	14	24	14	24	14	22	14	20	14	20	14	19	14	18	14	17
15	28	15	29	15	28	15	27	15	25	15	25	15	23	15	21	15	21	15	20	15	19	15	18
16	1 March.	16	30	16	29	16	28	16	26	16	26	16	24	16	22	16	22	16	21	16	20	16	19
17	2	17	31	17	30	17	29	17	27	17	27	17	25	17	23	17	23	17	22	17	21	17	20
18	3	18	1 April.	18	1 May.	18	30	18	28	18	28	18	26	18	24	18	24	18	23	18	22	18	21
19	4	19	2	19	2	19	31	19	29	19	29	19	27	19	25	19	25	19	24	19	23	19	22
20	5	20	3	20	3	20	1 June.	20	30	20	30	20	28	20	26	20	26	20	25	20	24	20	23
21	6	21	4	21	4	21	2	21	1 July.	21	31	21	29	21	27	21	27	21	26	21	25	21	24
22	7	22	5	22	5	22	3	22	2	22	1 August.	22	30	22	28	22	28	22	27	22	26	22	25
23	8	23	6	23	6	23	4	23	3	23	2	23	31	23	29	23	29	23	28	23	27	23	26
24	9	24	7	24	7	24	5	24	4	24	3	24	1 September.	24	30	24	30	24	29	24	28	24	27
25	10	25	8	25	8	25	6	25	5	25	4	25	2	25	1 October.	25	31	25	30	25	29	25	28
26	11	26	9	26	9	26	7	26	6	26	5	26	3	26	2	26	1 November.	26	1 December.	26	30	26	29
27	12	27	10	27	10	27	8	27	7	27	6	27	4	27	3	27	2	27	2	27	31	27	30
28	13	28	11	28	11	28	9	28	8	28	7	28	5	28	4	28	3	28	3	28	1 Jan. '59.	28	31
29	14	29	12	29	12	29	10	29	9	29	8	29	6	29	5	29	4	29	4	29	2	29	1 Feb.
		30	13					30	10					30	6	30	5			30	3	30	2

Explanation of the Calendar, with some Remarks upon the Japanese Division of Time.

In the foregoing calendar it will be observed that the columns are numbered 1, 2, 3, 4, &c., beginning at the left hand, each column being divided. The figures to the *left* of the dividing line represent the Japanese day of the month, whilst those to the *right* represent the corresponding dates according to English computation.

The calendar commences at the left hand upper corner with February 1st, 1858, according to the Japanese computation, which agrees with our 14th of the same month. At the lower end of column 11, begins January 1st, 1859, and nearly opposite, in column 12, begins February 1st, from which may be constructed a complete calendar for that year. All that is necessary to be borne in mind, is that one-half of the months in the year have 30 days each, and the other half 29, making the total number of days in their year 354.

The Japanese day is divided into twelve divisions, the first six (sunlight) divisions beginning at sunrise and ending at sunset, and the second six (night) divisions commencing at sunset and ending at sunrise.

As the subdivisions are unequal and are constantly changing, it would seem to suggest an impossibility of constructing an instrument to indicate them equally. Such, however, is not the case absolutely, as will be seen from the following description of their indicators or clocks. These instruments are in shape somewhat like the old-fashioned eight-day hall clocks, and are generally from twelve to sixteen inches long, two and a half inches wide, and two inches through. The upper portion for three or four inches in length is enlarged to receive the works, the remainder answering for a case, as well as a guide, for the weight or motor, which is wound up by a cord, &c., like the ordinary clock.

There is arranged in a slot in the front of the case a series of metallic numbers from 1 to 6, counting from top to centre, and from centre to bottom. These are duplicated, and so fixed as to be separated or drawn together as circumstances of changing seasons may require. To the weight is fixed a pin projecting from the case sufficiently far to admit of a pointer or index hand, which descends with the weight, and marks the beginning, duration, and termination of each subdivision.

During the longest days of summer, when there are some 15 hours from sunrise to sunset, the numbers are set apart sufficiently far to require about 2·5 hours to travel a single sunlight division, while the night division of the same 24 hours requires but 1·5 hours.

In mid-winter, or what is termed the short days, the reverse of the above obtains—the night subdivisions become longer, and the day shorter.

This system will no doubt soon give way to our method, as English watches and clocks are being rapidly introduced into Japan.

The Japanese new year commences on a day corresponding to our 23d of January.

S.

For the Journal of the Franklin Institute.

On the Erie Experiments on Steam Expansion. By SAMUEL McELROY, C. E.

In the paper which was published on this subject in the October and November numbers of this *Journal*, objection was made to the conclusions of the Board of Naval Engineers, as to the principle, the method, and the results of its experiments. Although the report was received in April, through the courtesy of Engineer in Chief Isherwood, towards whom, as well as other members of the Board with whom I have been in former times associated, no differences of professional opinion can affect my esteem as an engineer or my regard as a friend, it was with much reluctance and after long delay, in the hope that some other gentleman would meet the obvious necessity of a formal and public protest against its assertions, that I completed the notes made at the time of its first perusal, and placed them on record.

It was due to these gentlemen by every law of etiquette, that such a protest should be made with the carefulness, the analysis, and the dignity which characterize all investigations prompted by an educated regard for scientific truth, and this was felt to be particularly required, in view of the pointed and unequivocal manner in which matters of time-honored faith and practice were rejected and contravened.

Beyond such a formal protest it was not my intention to pass. My daily engagements, like those of all my brethren in harness, scarcely yield the leisure, if I had any personal inclination, to spend much time in what seems to me a retracing of the old formulæ, geometrical and arithmetical, which prove "twice two to be four." It is enough to have denied the premises of the challenge, which now demands me to believe and figure otherwise, and to have done this with sufficient elaboration of the arguments of my faith.

There is, however, in the reply of a member of the Board, in the December number, to this protest, enough of admission and explanation, to enable us to sum up the matter without much discussion, and without involving a controversy in which I am not at liberty to indulge; and I therefore propose to notice this reply as to a point or two presented.

In discussing the principles of experiment violated at Erie, it was claimed generally that the problem in which all engineers are directly interested "is defined by the amount of work to be done, and the most economical method of doing it," and consequently that the real matter at issue is—"whether it is cheaper to carry high steam and expand, or low steam and follow full stroke." As the Board maintained the same steam pressure, and reduced the amount of work done to suit the various grades of expansion tested, we claimed that the benefits of increased pressure were denied the measures of expansion, on this general principle.

Mr. Stimers replies to this that we do not "appear to be conscious

that this mode of regarding the subject unites the question of high pressure with that of expansion; whereas the experiments were instituted, not to ascertain the relative economy of using steam of different pressures, but "the relative economy of using steam with different measures of expansion."

He then quotes a page or so of the report, to show that "they recognised fully and stated clearly, the advantages of high pressure steam." So far then as the question of practical operation is at issue, it is here admitted, that the results would have been much more favorable to the increasing grades of expansion, if the Board had handled the *Michigan's* cylinder, with a regard for economical results, and in the manner adopted by educated men with a view to such results. A very important distinction is therefore drawn between an abstract question under experiment and a question of absolute economy.

But Mr. Stimers forgets in this admission, that the report which he signed, distinctly denies that greater economy in result would have been thus realized. On pp. 33 and 34, a case is presented which "involves not only the effect of different measures of expansion *per se*, but of different initial cylinder pressures." For such a case as this, the following argument is given:

"The [tabular] numbers which express the comparative economic efficiency of the different measures of expansion in rapport of total power, will also express their comparative economic efficiency in rapport of net power when the initial cylinder pressure is adapted to give the same net pressure with the different measures of expansion. Hence the quantities on line 21 of table No. 2, express the comparative economic efficiency of the different measures of expansion in rapport of fuel, when the same engine is employed with the same velocity of piston and net pressure upon it. [Line 21 gives these quantities: 11-12ths cut off 1·000, 4-45ths 0 915. 7-10ths 0·882, $\frac{1}{6}$th 0·877, 3-10ths 0·874, $\frac{1}{4}$th 0·852, 4-9ths 0·840.] This deduction is rigorously exact, if we except the modification due to the difference of temperature in the cylinder during a stroke of the piston; but the correction for this, whatever may be its amount, will be in favor of the *less measures* of expansion, because, as with them, in order to obtain the same net pressure on the piston, the initial cylinder pressure, and consequent temperature of the entering steam, will be much less, while the temperature of the back pressure remains constant, the difference will be much decreased, and the condensation due to these extremes proportionally lessened."

Whatever, then, may have been the preliminary arguments of the Board, its summing up of results sacrifices consistency, and condemns the very clear and intelligent admission of one of its members, while at the same time the particular line, 21, referred to, gives us a striking illustration of the anomalous results obtained through the erroneous method of experiment adopted.

To the objection also made on the score of principle, that the Board could not reduce the coal combustion from 18·52 pounds to 3·79 per sq. ft., the engine load from 29·8 to 8·8 lbs. per sq. in. of piston, and the revolutions from 20·6 to 11·17, without violating the established doctrine of maximum useful effect, we have no answer, and therefore credit Mr. Stimers with a negative assent.

In place of this we have an argument to show that all the objections in detail, which cluster around this violated principle, do not influence "in the slightest degree, the only measure of the cost of the power

developed by the engine," which is pronounced correct by the Board, and that is the weight of water by tank measurement, consumed per hour per horse power. This means to say then that it can make no difference to the economy of an engine, how much coal is wasted by imperfect combustion, or how much water is wasted by perceptible and imperceptible leakage, by priming, and otherwise, or how much violence is done the development of power in the steam produced from the water evaporated. All these sources of error and loss are merged in the asserted infallibility of the tank measurements, which in these experiments have a range of difference from the record of the indicator from 3 to 37 per cent. And without being able to deny the accuracy of the indicator, it is a singular fact, that the Board should have been willing to endorse the tank so implicitly.

To the objection that the results of Experiments Nos. 1 and 2 are combined, because no interval elapsed between them, we are told that "there was nothing to be changed except the damper in the smoke-pipe and the point of cutting off." This admission sufficiently illustrates the reliance which is to be placed on the distinct coal accounts given, and the process of changes in coal combustion and engine resistances; and it is a singular comment on the necessity otherwise suggested of occupying *several hours* to adjust the engine to the *normal conditions* of each experiment.

Nor is our assertion contradicted, that the coal account for each experiment is not accurately determined. The possibilities of error are fully admitted, on the plea that they could not be very important. Whatever may be the per centage of error at issue, the question of correctness in method has an importance far superior to any single detail in result.

As to the question of back pressure, it is a sufficient admission that one of its prominent measures is the "weight of steam discharged at the end of the stroke." In these experiments, prejudicial as we have shown them to be to the available benefits of expansion, we find on the basis of the comparative work done, that between 11-12ths and 4-45ths cut-off, while the actual weight of steam used, per indicator, was in the proportion of 966 to 146, the work done was as 343·9 to 86·5, whereas the proportionate work for the shorter cut-off should be but 52, showing that about 40 per cent. less steam would meet the ratio of work, and by consequence that there is no propriety whatever in assuming a common measure of back pressure for different measures of expansion.

The explanation of the friction of the load, which was taken at 2·1 pounds per square inch of piston, whether the load was 29·2 or 7·7 pounds, and whether the speed of the wheels was 20·6 or 11·16 revolutions, on the ground that 2·1 pounds represent the "constant pressure" caused by the "gravity of the different parts of the engine," introduced as an element of comparative measure for different expansions, is still far from clear to our "looseness" of observation. It is not a supposable case, that the parts of an engine are at any time in-

dependent of their load and speed, so that a uniform resistance may be attributed to all variations of either.

Nor can we understand that boilers at work under pressure, can possibly be in the same condition of protection from leakage as when standing cold. Mr. Isherwood's experiments on the *Prosser Boiler* showed an imperceptible leakage of 7·89 per cent., and all boilers under steam must waste water, more or less, until they are made of something less porous than heated iron and expanding tube sheets.

All these matters of detail in experiment, and the questions of back pressure, frictional resistance, indicator diagrams, and the like, in none of which is the report properly sustained, are, however, of minor consequence when compared with the main admissions we have noticed; and, in fact, the entire tenor of this reply is summed up in the following singular apology:—

"The careful reader will observe as very prominent in the foregoing quotation from the report of the Board, that it was not endeavoring to ascertain how much it was desirable to expand the steam in *existing engines*, but in those which were yet *to be built*, and in which proportions could be given that would do the required work in the most economical manner."

"It will be observed in this quotation from the report, how completely the Board sank all considerations of *existing engines* in its search for the true principles which should govern *future constructions.*"

Precisely what kind of a construction this new style of engine is to be, the report does not disclose; but it is clear, at all events, that we have been right in denying the correctness of its conclusions so far as they affect the several classes of engines now in use, or formerly used. When the new motor appears, we are to find that it is more effective under low steam than under high steam, and under a throttle in place of a cut-off; that its back pressure shall be always a minimum under all conditions of service; that the friction caused by the gravity of its parts shall be constant for all work; that it shall work equally well and as economically under light or heavy loads, at slow or quick speeds, and with any variations of coal combustion; and, last of all, that it shall be independent of the mechanical forces which, by inertia and momentum, now control the doctrine of expansion. To such an engine as this, and not to the *Michigan's*, the elaborate tables of this report prophetically apply. All this is very well, and in the meantime the engineering world will be permitted to exercise its faith in Mariotte, and Morin, and Weisbach, as usual.

This explanation solves a difficulty which otherwise affected us. Having had occasion in engine designs for a very important work to examine all the experiments or records within reach as to certain classes of engines, including the "double cylinder," we had noticed among various other testimonies, a paper on *Double Cylinder Marine Expansion Engines*, in the *July* number of this *Journal* for 1860, in which the writer uses the following language generally, and particularly towards Mr. Isherwood's *Precedents:*—

"From this table, it would appear that where the heat of the steam is neither increased nor diminished by extraneous influences, any *expansion* of the steam causes it to be

superheated, and not condensed, as some have erroneously asserted, basing their assertion upon the laws of steam as given by Regnault.

"A little reflection must convince any one not carried away by a kind of *scientific fanaticism*, that the yielding of the piston in the cylinder to the pressure upon it affects the steam only by giving it an opportunity to expand. What, then, becomes of Prof. *Joule's* theory that condensation is caused by a rendition of power on the part of the steam? It is painful to know that such absurd doctrines are advanced by men of learning and position, and that they are proved to be correct, and adopted into the calculations of others equally learned and high in position."

The writer discusses this matter at considerable length, showing the absolute gain by expansion *in the cylinder*, and the absolute gain of using a combined engine which is obliged to expand three times any way, and cuts off on the main valve besides at one-quarter.

Whatever difficulty we might have had in reconciling the emphatic and *demonstrated* argument of this paper, with the equally emphatic and directly opposing argument of the Erie Board, Mr. Stimers happily relieves by this opportune explanation, which now informs us that all the Erie discussions are to be taken in a Pickwickian sense, as to all present classes of engines. We were entirely in the right to have demonstrated the "absurd doctrine" of the Erie Board on the basis of present practice, and have only erred in our inability to eliminate from the report the latent prophecy of a new form of motor, to which it solely applies. Mr. Stimers' correction will, therefore, prove very serviceable to the "large number in the profession" who read professional papers with reprehensible "looseness," and could not otherwise appreciate the profound depths of the report. They will undoubtedly express their regrets that he did not by a foot note, or in some other plain and reasonable manner, append this context to that document before signing it.

Having extended our examination of this application of high measures of expansion by double cylinder engines into an elaborate research, assisted by actual experiments of a close and satisfactory character, we found it very clearly established at last, that the same benefits could be attained much more advantageously in single cylinders properly arranged; and we therefore suggest to this gentleman a continuation of the same research, in order that he may be, if possible, yet more positive in his denial of the *Joule* theory, and may continue in the consistency of his faith as to the present steam engine —mythical engines and abstract calculations not being gifted with a due modicum of horse-power for immediate work.

Without pausing to congratulate him on the admirable manner in which we are thus enabled to preserve our respect for his consistency in a profession where demonstration is absolute when in accordance with plain, natural, mechanical laws, and in a case where inconsistency would be fatal to his reputation as a *practical* man, we proceed to express our pleasure at finding from his remarks that the great and fundamental principle of all engine motion, which we referred to, has sufficiently attracted his attention to induce a trip or two in New York Harbor on the *Richard Stockton*, to study her engine in motion.

Possibly from a somewhat hasty reading of our suggestion, he seems

to have understood us to say, that "as the *inertia* of the mass—the motion of which is accelerated during the first half of the stroke and retarded during the last half—absorbs a portion of the power of the steam while being accelerated, and returns it again while being retarded, the engine works more smoothly and properly when cutting off at less than half stroke than when following beyond that point." This he calls "visionary speculation."

Now we did not assert that the *inertia* was either accelerated or retarded, not being aware that the idea of motion could properly be associated with inertia; that would be a "visionary speculation" of course, unless Mr. Stimers was inadvertently recalling that proposed novelty which may possibly possess inertia in some other state than that of rest. Nor did we say anything about an engine working "more smoothly and properly" with less than half cut off. What we did say was this:—

"To overcome the inertia of an engine, a certain surplus pressure must be applied to the piston, which corresponds with initial pressure, and is exceeded at no after point of the stroke. The mass being thus put in motion by charging it with surplus power, it is a mechanical absurdity to continue the initial pressure any further than will suffice to complete the stroke by virtue of the surplus power imparted at the commencement."

We remarked in connexion with this, that by this principle, "we come back again to the doctrine of maximum useful effect," which apprehends both load and velocity; and we also said that the "maximum velocity of motion" could be imparted to an engine before it reaches the half stroke.

If Mr. Stimers means to say that this theory of engine motion is a "visionary speculation," and has commenced sundry excursional trips to obtain evidence on the subject, arguing his correctness from the first trial because he found a certain case of high speed incompatible with high expansion, we shall be happy to refer him to a very large class of high speed engines, which do cut off very short with great economy, and then to a class of low speed engines which also cut off very close, both classes being entirely consistent with the doctrine urged, and respectfully suggest that maximum useful effect involves the element of load as well as velocity. It is also readily demonstrable that a high range of economical result depends not only on thoroughly educated design, but on thorough scientific management. We have had considerable experience of the difference between an engine carefully designed to fulfil a certain purpose, and the management of the same engine in the hands of what we used to call in "our date," "intensely practical men," a class entirely educated through their fingers and thumbs, and who, by the way, are particularly vindictive towards any other school than their own.

With regard to this matter of engine motion, we cannot but feel that Mr. Stimers has taken precisely the right course. Close study of all results heretofore obtained, sifted and digested by applying the recognised laws of mechanical forces, in connexion with accurate observation and experiment, will always guide an unprejudiced student into the path of true practice. And pursuing this commendable course,

we have no doubt that in less time than elapsed between the contribution to the *Journal of the Franklin Institute* which we have noticed, on *Double Cylinder Engines*, and the compilation of the *Erie Report*, this gentleman will fully comprehend how rigidly correct we are, as to the present steam engine, in declaring that "the idea of assuming full steam travel as a basis of comparative mechanical action, is a misapprehension of engine duty."

This sums up, I believe, all the questions at issue of paramount importance. As to the benefits of higher steam in connexion with expansion, and as to all the other questions of principle and method which characterize these experiments, all that I claimed appears to be sufficiently admitted in relation to all *existing engines*. I have nothing to offer prematurely about prophetic combinations; these may be freely conceded to the new school of speculation and design.

There is but one thing more to say, and that is necessarily brief. This member of the Board occupies the first page and other portions of his remarks in asserting my incompetency to "comprehend" the report, while indulging in a sneer at my "boldness, intelligence, and literary ability;" also crediting me with "slight practical experience," apparently with the object of disarming my criticism. In that comprehensive school of the profession which I left to enter the Engineer Corps of the Navy to accomplish a certain purpose, and to which I returned after my resignation, a resort to such personal arguments is considered a confession of judgment. For the sake of all that is courteous among gentlemen, and dignified in scientific discussion, and truthful, I hope I am correct in supposing that these things were written in haste and have been regretted at leisure. One thing is certain, and this is, that nothing further of the kind will be noticed in the *Journal of the Franklin Institute.*

For the Journal of the Franklin Institute.

Construction of Arcs of Circles having Large Radii, the Versed Sine being Unknown. By J. K. Whilldin, Civ. Eng.

The following method of constructing arcs of large circles, I have found to be very convenient, especially when making full size drawings of details attached to large cylinders and other circular objects.

When beam compasses exceed five or six feet in length, they become rather clumsy to manage with ordinary drawing boards, and it becomes necessary in laying down arcs of large circles to obtain certain points in the desired curve, and trace a line through them by means of a batter and weights.

With the ordinary modes of constructing these curves, the versed sine is assumed as *known*, but it frequently happens that this item is unknown, and we have only the value of the radius as a basis of operations. True, we may calculate* with this datum the versed sine corresponding to any assumed chord, but this is a tedious process, and

* Versed sine $=$ Radius $- \sqrt{\text{Radius}^2 - \left(\frac{\text{Chord}}{2}\right)^2}$.

with very large radii and small chords, unless we extend the operation to many places of decimals, we do not obtain any considerable accuracy.

The advantage of the method here given is, that while it requires no calculations, the points obtained by it are as correct as those which would be found by the beam compass, could the latter be used.

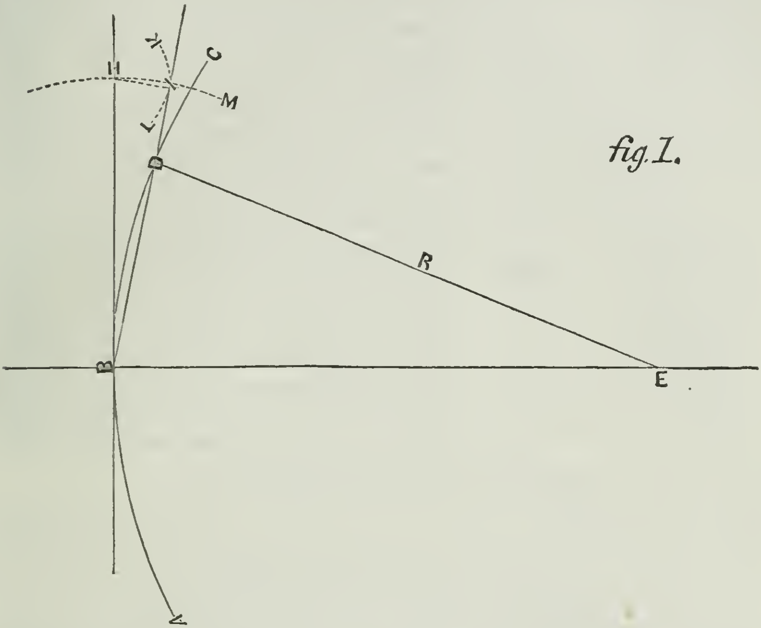

fig. I.

Let A B C be the arc we desire to construct, R the known radius; with the radius R taken on any convenient scale of equal parts, describe the indefinite arc H M from the point B; also take $\frac{1}{2}$ of any assumed chord B D on the same scale as R, and describe the arc L I K from the point H; now from the point B draw a line tangent to the arc L I K, and on the line thus drawn lay off from the point B the assumed chord B D. Then will the point D be in the arc sought, and the curve may be run through it, and other points found in the same manner, by means of a batten.

Example.—Suppose R = 10 feet, and suppose we take a chord B D = 14 inches.

We will begin by taking R, say on a scale of $1\frac{1}{2}$ ins. to the foot, which will give us 15 ins. as a radius to describe an arc H M from the point B. Again taking $\frac{1}{2}$ of 14 ins. (the assumed chord) on the same scale, we have $\frac{7}{8}$ths of an inch as a radius to describe the arc L I K from the point H; drawing the line B I, and laying off on it from the point B the actual length of the chord B D = 14 ins., we obtain the point D through which to run the curve.

The foregoing construction is based on the well-known fact that the

angle H B D contained between the chord and tangent is one-half of the angle B E D, which is measured by the chord B D; and the taking of the radius R and $\frac{1}{2}$ the chord B D on a scale of equal parts, is merely a convenient mode of constructing the angle H B D.

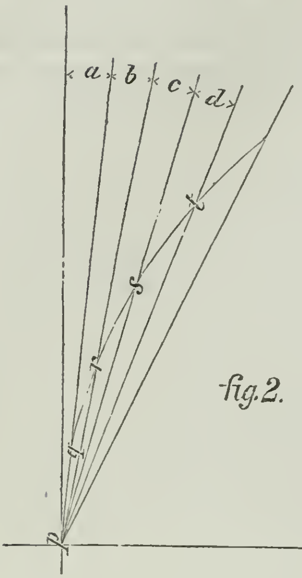

fig. 2.

The inclination of the chord being thus found, and its length B D being already known, the point D is therefore determined.

The angle H B D may also be constructed by taking the chord and the diameter of the large circle, both on the same scale of equal parts.

Railway curves are sometimes projected by methods analogous to the above by means of the transit and chain. Thus, in fig. 2, if *a*, *b*, *c*, &c., be equal angles, and we commence at the point *p* and lay off the equal distances *pq*, *qr*, *rs*, &c., then will the points *p*, *q*, *r*, *s*, &c., be points in a circle, whose magnitude depends on the equal measures *pq*, *qr*, &c., or, if these be constant, on the equal angles *a*, *b*, *c*, &c.

Washington, Dec., 1861.

For the Journal of the Franklin Institute.

On Electrical Machines. By E. S. Ritchie.

The electrical machine known as the Ruhmkorff Induction Coil, resulted from the researches and discoveries of Faraday, Henry, De la Rive, Fizeau, and others.

Mr. Ruhmkorff of Paris was the first to construct this instrument, following the arrangement of Faraday, surrounding an electro-magnet by a helix of insulated copper wire, to which he applied the automatic interrupter of De la Rive.

The important discovery of the action of the condenser to the interrupter, by which the intensity of the induced current is increased so as to pass an interval, is due to Fizeau, and was immediately adopted by Ruhmkorff.

The limit which Ruhmkorff attained in his most powerful coils was to throw the spark less than one inch.

Mr. Hearder, in 1857, improved the apparatus by more carefully insulating the helices, and obtained sparks of three inches.

During the spring of 1857, I attempted the construction of the instrument, following the general form adopted by Ruhmkorff; but, beyond the narrow limit already attained, I found it impossible to make one which would not destroy itself by the discharge taking place within the helix, between the outer and inner portions, which

were necessarily brought in near proximity, depending alone upon insulating media.

I saw that this was an insuperable difficulty unless a mode of construction could be devised by which the portions of the helix should be separated by a distance nearly equal to the tension of the electricity induced in the wire. I wound a coil with the strata laid in conical form, each course beginning upon the bobbin, and winding up a cone of 45° until the diameter of the exterior was attained; then an insulation of rubber was overlaid, and another course wound in like manner, and so on: the experiment proved successful. I then devised a mode of winding the wire in planes perpendicular to the axis, alternately running from the inner to the outer and from the outer to the inner diameters of the helix, insulating between the strata; and, in July, 1857, instruments were made giving sparks twelve inches in length.

Prof. Wm. B. Rogers, at the meeting of the British Association held in Dublin in 1857, stated the power of my coils, and soon afterwards I received from John P. Gassiot, V. P. R. S., and from Prof. Forbes of the University of Edinburgh, orders for instruments of twelve and nine inches, which were sent them the following spring.

Until July, 1859, no instruments had been made by Ruhmkorff of greater power than three or four inches in length of spark, when he received one of my coils, which he dissected and copied, as will be evidenced by the following

Statements by Prof. MacCulloch.

1. In the summer of 1858, I ordered of Mr. Ruhmkorff one of his induction coils, similar to that for which the Academy had awarded him a prize. In my letter, I stated that Mr. Ritchie professed himself ready to surpass whatever might be its power, and mentioned that he had made for Columbia College a coil giving twelve inches sparks, with a pile of four carbon cells. In the reply of Mr. Haskell (my Paris correspondent) it was stated that Ruhmkorff expressed surprise that this result had been obtained from four cells only. He did not accept the challenge, but agreed to make one of his best and most powerful coils with other miscellaneous apparatus.

2. In May, 1859, having obtained nothing from Mr. Ruhmkorff, I visited him in Paris, and urged the prompt execution of my order; he considered my request that he should send to New York a machine to be surpassed by one of a competitor as an unfair proposition. To this I replied that I would request Mr. Ritchie to send to Paris the most powerful coil he could make. With reference to my order for a large coil, he showed me the wreck of the only one he had attempted to make, and informed me that it had destroyed itself by the spark passing through the coil breaking down the insulation, &c., and he was unwilling to make any but his ordinary coils (price 300 francs), which, however, with other apparatus, he agreed to furnish promptly.

3. Supposing that Mr. Ruhmkorff would be happy to compare the coil of Ritchie with his own and that of Hearder, desiring to gratify him, and not for an instant doubting that he would accord to Ritchie all that is peculiar in his perpendicular system of winding the second-

ary bobbin, I presented to Mr. Ruhmkorff, in July, 1859, one of Ritchie's coils giving sparks of seven inches, which he dissected, for the purpose of examining its construction.

4. About the same time, I ordered from Mr. Ritchie the most powerful coil he could make, and requested him to send it to Paris. This instrument arrived in September, but was in the hands of the Custom House officers until November. When received it was taken to Mr. Duboscq's, who politely offered me the requisite facilities for experimenting with it. It was tried in the presence of Mr. Jacobi, of St. Petersburg, and of MM. Foucault, Lipajous, Nachet, and Duboscq. Afterwards it was exhibited privately to MM. Jamin, Sénaumont, Verdet, Desains, Froment, Du Moncel, Baron Thénard, Gaverret, and others, and publicly to the students of the École de Médecine. By request of M. Jamin, it was also shown to the general commanding and several of the professors of the Polytechnic school.

5. During the month of February, 1860, I met M. Jamin, who told me that the Polytechnic school had for more than two years urged M. Ruhmkorff in vain to make for its cabinet a powerful coil; that in the month of March it would be necessary to close the account of expenditures for the current fiscal year, and that unless Ruhmkorff should then deliver the long-solicited coil, the Polytechnic school would be glad to buy that of Mr. Ritchie. In the month of March, Mr. Ruhmkorff delivered to the Polytechnic school the coil ordered from him.

6. In May I saw the said coil at the Polytechnic school, and was informed by M. Jamin that the secondary bobbin is wound in portions perpendicular to its axis (Ritchie's system); also that it gave sparks of 33 to 40 centimetres (13 to 16 inches), about the same as those of Mr. Ritchie's coil.

7. In June, Mr. Ruhmkorff showed me in action a coil just finished by him for M. Du Moncel, a duplicate of that of the Polytechnic school. The sparks were of about the average length of those from the Ritchie coil. Mr. Ruhmkorff gave me as the length of the sparks for both the coil of the Polytechnic school and that of M. Du Moncel, 33 to 40 centimetres; and he stated that the secondary bobbin is divided (fractionné) perpendicular to the axis. * * * *

(Signed) R. S. MacCulloch.

New York, September 8th, 1860.

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The French scientific journals immediately noticed the instruments made by Mr. Ruhmkorff, awarding to him the credit of all the improvements made. The Vte. Du Moncel, Ganot, and other French writers who have published descriptions of the instrument, though fully conversant with the facts, have carefully ignored them. Prof. MacCulloch wrote to Vte. Du Moncel to correct statements in the *Cosmos* which he considered unjust to me, but no notice was taken of his request.

I am induced to make this statement only because my silence has been construed into an admission that I had made claims which I could not substantiate.

Boston, December 15th, 1861.

New Fusible Alloys: Remarks on determining the Melting Point of Metals, &c. By B. Wood, M. D.

To the Editor of the Journal of the Franklin Institute.

Seeing that the "fusible metal" described by me some time ago, (consisting of cadmium 1 to 2 parts, tin 2 parts, lead 4 parts, bismuth 7 to 8 parts, and melting between 150° and 160° Fah.,) has been viewed with some interest by men of science, I take the liberty to offer through your *Journal* a short description of another alloy, which perhaps has equal claims to scientific notice. It consists of

Cadmium 1 part, Lead 6 parts, Bismuth 7 parts.

This alloy melts at about 180° Fahr., being nearly midway between the melting point of the old fusible metal, consisting of the *three* metals, tin, lead, and bismuth, and that of the alloy above mentioned, consisting of the *four* metals, cadmium, tin, lead, and bismuth. It is remarkable as exhibiting the fluidifying property of cadmium in certain combinations—(a property to which attention was directed in vol. xl. No. 2, of this *Journal;*) and also in the fact that, while the mean melting point of the constituents composing it is much higher than that of those composing the old fusible metal discovered by Newton, (being in the former case about 540°, in the latter 500°,*) it melts at a much lower temperature. It is more fusible than any other *alloy* yet known consisting of but *three* metals.

It appears to be the most fusible form of mixtures of cadmium, lead, and bismuth, any material variations from the proportions stated resulting in a higher melting point. Thus, taking the extremes on either side, a mixture of 1 part of cadmium, 1 of lead, and 2 parts of bismuth, barely softens in boiling water, while one of 1 part cadmium, 10 parts lead, and 11 bismuth, becomes fairly soft. A mixture of 1 cadmium, 6 lead, and 6 bismuth, barely *melts* or fluidifies in the same, and of 1 cadmium, 6 lead, and 8 bismuth, becomes fairly fluid. From these points the fusibility is increased or diminished as we approach to or recede from the proportions of the formula.

The alloy presents a clear, brilliant, metallic lustre. It does not tarnish readily; whereas the combinations of lead and bismuth are remarkable for the facility with which they not only tarnish, but oxidate upon the surface. Its color is what would be denominated "white," but more strictly a bright bluish grey, very nearly resembling platinum in hue and lustre. When cast, its free surface presents a white, frosted appearance. It is very flexible in thin plates, and the fracture is hackley, but when broken in thicker bars the fracture is smooth, resembling that of tempered steel. It is malleable, although not perfectly so, cracking upon being reduced one-third to one-half of its thickness. In hardness it is the same as bismuth, or nearly the same as an alloy of 2 parts of lead and 1 part of tin (coarse solder), which it resembles more nearly in other respects.

* Taking the melting point of tin as 440°, of bismuth 480°, lead 600°, and cadmium 600° (being the same as lead, notwithstanding it is placed in most of the books as low as 442°), then the mean of 1 part tin, 1 lead, 2 bismuth, is 500°; or of 3 tin, 5 lead, 8 bismuth, 510°; the mean of 1 cadmium, 6 lead, 7 bismuth, = 540°. That of 1 cadmium, 1 tin, 2 lead, 4 bismuth, 520°; or of 1½ cadmium, 2 tin, 4 lead, 7½ bismuth, 518°.

It may be that more approved methods of measuring temperature will give the alloy a still lower melting point than above ascribed to it.

I see by a notice in the June number of this *Journal*, copied from a European publication, that Lipowitz gives my "fusible metal" a much lower melting point than I had indicated. He found, it is stated, that an alloy composed of 3 parts cadmium, 4 tin, 8 lead, and 15 bismuth, "softens between 131° and 140° Fahr., and near 140° becomes perfectly fluid;" whereas, finding the most fusible formula to become fluid so as to be fit for use in casting, at 160° F., and to harden at 150°, I designated its fusibility as "between 150° and 160°." Of different variations the proportions of the following formulas, or proportions intermediate between the two, give the lowest melting point, which appears to be identically the same in either case, being 150°, or very nearly, viz:

Cadmium 1 part, Tin 1 part, Lead 2 parts, Bismuth, 4 parts,
or " 3 parts, " 4 parts, " 8 " " 15 "

Determining the melting point of these by means of a mercurial thermometer of high range, and not graduated to indicate fractions of degrees, the bulb being immersed one-fourth of an inch in the melted metal contained in a small porcelain crucible, it was observed that, on cooling, the metal was fluid around the bulb at 150°; at 146° or 147° it was still soft; the mercury then *rose* to 150°, and after remaining stationary there some moments the metal congealed completely, after which the mercury still remained at the same point for some moments before it began to fall. In the proportions of 1 part of cadmium, 2 parts of tin, 4 of lead, and 7 of bismuth, the alloy congeals at 154°.

There are difficulties in the way of exactitude in measuring the melting point, and we find a want of uniformity in the results of different experimenters, owing partly, perhaps, to imperfections in our instruments, partly to the different modes of using them, and partly to the want of a uniform rule and standard of measurement. What *is* the "melting point"? or what is the precise condition of a metal when it is said to "melt"? Are we to reckon from the point at which it softens? or fluidifies? or congeals? Some alloys pass from one condition to the other at nearly the same temperature, while with others there is a difference of fifty degrees or more. There is generally, too, a difference between the point at which metals *become* soft or fluid in heating, and that at which they *remain* fluid or soft on cooling, however carefully the process be conducted. Again, *how* should we measure the temperature of a metal in the melted state? Should the bulb of the thermometer be submerged, or is it sufficient to simply dip the lower extremity? If we adopt the latter mode, noting the temperature, and then plunge the bulb deeper, the mercury will be observed to rise. In taking the temperature of the atmosphere, the medium envelops both bulb and stem. When the bulb is partially immersed in a hot liquid, the upper part of the contained mercury radiates a portion of the heat received by conduction from the lower. Suspending the bulb in hot water to the depth of half an inch, the mercury in the stem

stood at 184°; while on partially withdrawing it, so that only its extremity remained in the water, the mercury fell to 170°. In other instances the difference was about 15°, more or less. The lower strata of the fluid in such cases may indeed be hotter than those near the surface, as receiving the heat sooner and parting with it later: but this argues a difference of temperature in the upper and lower strata of mercury in the thermometer bulb when placed in like situation, and if it were long enough the effect of the heat acting upon the lower extremity might be neutralized by cold applications to the upper. A piece of metal may be held between the fingers by one end while it is melting at the other. It is true, metals when fluid conduct heat more readily. But if we examine different portions of a mass in this condition, we shall find marked inequalities of temperature, (nor is equilibrium restored so long as the metal remains fluid, except the whole be kept in this condition in a uniform medium.) Thus, when cooling, the outer portions part with their heat faster than they receive it from the centre, and consequently are first to congeal.

But there needs no proof to show that the indications of the thermometer will be erroneous when the greater part of the bulb is in a cooler medium than the metal under examination. The facts referred to only show that the error may be greater than is generally supposed. They also point to difficulties in the way of obtaining exactitude by the other method. But, what is more directly to the present purpose, they speak the need of uniformity in the mode of measurement, on the part of those not provided with means of obviating these difficulties, that our *approximations* to the truth may be uniform.

When the bulb is immersed in the melted metal, the lowest temperature at which it will move freely may be taken as the melting point, and that at which it adheres, as the point of congelation. The cylindrical bulb is more convenient than the globular, and it would be better still if in shape of an inverted cone.

INDIANAPOLIS, Ind., Dec. 20, 1861.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, December 19, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President, }
Isaac B. Garrigues, Recording Secretary, } Present.

The minutes of the last meeting were read and approved.

A letter was read from the Liverpool Literary and Philosophical Society, Liverpool, England.

Donations to the Library were received from the Royal Astronomical Society and the Chemical Society, London; Frederick Emerick, Esq., and Hon. W. D. Kelley, Washington City, and Charles Ellet, Jr., Esq., Georgetown, D. C.; and Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of October was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (9) were proposed, and the candidates proposed at the last meeting (13) were duly elected.

Nominations were made for officers, managers, and auditors for the ensuing year.

Mr. Washington Jones, Chairman of the Committee on Meetings, exhibited Amies' patent Universal Square, which combines five different instruments, viz: the try-square, the miter, the T-square, the graduated rule, and (what is entirely new) the centre square, for finding the centre of a circle. This instrument was made by J. R. Brown & Sharpe, Providence, R. I.

He next presented, from the same makers, a Centre Gauge, for adjusting the work in a turning lathe.

The same gentleman also exhibited a standard Scale of hardened steel, graduated from $\frac{1}{8}$th to $\frac{1}{100}$th of an inch by machinery, combining accuracy and cheapness. It was made by Darling & Schwartz, Bangor, Maine. All the above tools where presented by Messrs. Field & Hardie, of this city.

Mr. Jones also exhibited a Razor Strop, the invention of Mr. C. Y. Hayne, the polishing cushion of which is stuffed with sand, instead of lying flat on the body of the strop as usual.

Mr. Howson, of the Committee on Meetings, submitted a Watchman's Clock, the manufacture of Messrs. Code, Hopper & Gratz, of this city. By means of this clock, it may be readily ascertained whether a watchman has remained at his post during the proper hours. A slit is made in the face of the clock, through which the watchman introduces a pencil at stated intervals to mark a revolving dial; the marks on the dial show the hours at which he has been at his post.

Mr. H. also presented a great variety of Paper Tags and Collars, both plain, printed in colors, and embossed, made by the Lockwood Manufacturing Company of this city.

He also exhibited an apparatus, the invention of E. H. Bailey of this city, which may be readily attached to the lock of any door, to prevent the key being turned by nippers or other tools from the outside.

Mr. Howson then placed on the table a working model of H. G. Armstrong's Paper Bag Machine, as improved by S. E. Pettee; also a specimen of Photograph Album, made by Turner Hamilton.

Specimens of Envelopes made by a machine invented by Mr. Pettee were also exhibited by Mr. Howson. Envelopes made in this manner cost considerably less than those made by hand, and can be made at the rate of 30,000 per diem.

A patent Camp Trunk was exhibited by W. A. Andrews, the inventor. The lid of this trunk contains a folding bed or couch, and a table, being so constructed as to be easily removed without disturbing the other articles in the trunk.

A. L. Fleury, Esq., read the following paper on the Preservation of Stone, and some new methods of preparing a pure aqueous Solution of Silica:

The subject of the preservation of stone has recently been most

thoroughly discussed by some prominent English chemists,* and the writer thinks it is worthy of more special notice; less on account of the necessity of preserving *our* building stones, (these seem to be mostly selected with the very view for change, and we Americans have never, until perhaps very recent times, been over-anxious for the preservation of old buildings,) than of the great number of applications which we are able to make of a new material, *hydrated silica*, recommended for the preservation of stone.

The alkaline soluble silicates of soda or potassa, the water-glass of Fuchs, Kuhlmann, Liebig, and others, are too well known to be here described, and those desirous of being informed may read a very graphic description in the *American Journal of Science and Arts*, for September and October, 1861. These silicates will, however, give way to a better adapted and much purer article, to the *pure aqueous solution of silica.*

The manufacture of the alkaline silicates will not suffer thereby; on the contrary, after the real value and immense pecuniary and other advantages shall have permeated the American public, it will soon increase and develop itself on a most gigantic scale.

The progress in this department, however, is not confined to our more scientific English, French, and German neighbors; what they communicate to us as new facts, has been known for many years past in the United States. The gentlemen cognizant of these important facts, partially to escape the ever lurking harpies of speculators and patent thieves, partially to elude the attacks of some chemists, who declared it impossible for silica to exist in aqueous solution without the addition of an alkaline base, kept their own counsel, but will shortly exhibit such specimens as will far excel those of the English chemists.

The following extract from an article written by the editor of the London *Chemical News*, No. 100, p. 227, contains some valuable suggestions:

"No one who has critically examined the various projects for hardening and protecting stone, which have during the last few years been made public, can have failed to remark the great importance which, in the majority of instances, is attached to the action of silica. Thus, in reviewing the processes submitted to the Decay of Stone Committee, among the eleven proposals which have already been under consideration, no less than seven depend for their efficacy upon the action of this very substance under various conditions of employment. Advantage is taken of the mutual decomposition exerted between certain silicious compounds applied, and the materials constituting the building stone itself; or, otherwise, systems are founded upon the production of compounds from an alkaline silicate, and a soluble earthy salt, successively applied. The known properties of silica and of the class of silicates have, no doubt, powerfully contributed to the formation and establishment of this opinion. The facility and cheapness with which they can be manufactured on the large scale; their unalterability un-

* See the Report of the Committee on the Decay of the Stone of the New Palace at Westminster, London Chemical News, No. 97, p. 189; also, Jour. Frank. Inst., this number, p. 3.

der trying atmospheric influences; their all but complete indifference to energetic chemical re-agents—all point to silica as the one fit material upon which the ingenuity and experimental resources of our chemists and practical men may be expended with the greatest promise of success. Let only a sufficient amount of silica be compelled to enter and occupy the pores of the stone and incrust all the exposed surfaces; let it be employed in a state of hydration, or other suitable form, in which it may gradually combine with the earthy constituents it there meets, and with its action unfettered by saline impurities, the presence of which tends often to interfere mechanically with its successful employment, and the strong presumption is that the House of Parliament will endure, so far as the stone is concerned, as long as the Pyramids.

"The difficulty which besets many of the processes of silicification is, that along with the needful silica, so much superfluous, and, indeed, injurious matter is introduced, that the valuable qualities of the silica are in a great measure counteracted; the disintegration of the stone sometimes caused actually by the efflorescence of these extraneous substances, and the porous character necessarily induced as the consequence of the gradual removal of the soluble salts in juxtaposition with the silica undoing the binding and hardening action of this valuable material. From this train of reasoning, it became evident that if hydrated silica could but be deposited in the pores of a limestone or dolomite, without the assistance of potash or soda as a vehicle, and there be left slowly to enter into chemical union with the earthy bases of the stone, its action commencing unimpaired by the presence of extraneous salts, and its future efficacy undiminished by the progress of their removal,—that if this could be accomplished, there would be a far greater chance of ultimate success than has been offered by any plan yet made public.

"It is well known that silica can, by appropriate means, be obtained in the form of a pure aqueous solution, and it was to this liquid that we accordingly directed our attention. This solution can be made in several ways:

"1. By dissolving sulphide of silicium in water, when sulphuretted hydrogen is given off, and the silica remains completely dissolved, and in such quantity that the liquid gelatinizes when an attempt is made to evaporate it.

"2. By precipitating silica in the gelatinous state from an alkaline silicate, by means of acetic or other weak acid, and, after well washing, heating it for some time under pressure, with a small quantity of water in a closed vessel. A liquid is thus obtained which gelatinizes on addition of a saline solution.

"3. By passing gaseous fluoride of silicium over crystallized boracic acid, and separating the hydrofluoric and boracic acids by digestion with a large excess of ammonia, a hydrate of silica remains, which, when well washed from the above acids, is very soluble in water. This solution gives no precipitate when boiled, but leaves silica as an insoluble powder on evaporation.

"4. By the beautiful method recently pointed out by Professor Graham, in which advantage is taken of the new means of separating

bodies by *dialysis*. A solution of silicate of soda, supersaturated with hydrochloric acid, is placed on one side of a parchment paper septum, pure water being on the other side; in a few days the hydrochloric acid and chloride of sodium will be found to have completely passed through the diaphragm, leaving the silica in aqueous solution, and so pure that acid nitrate of silver fails to detect chlorine in the liquid. This solution remains fluid for some days, but it ultimately gelatinizes. We have generally adopted this last plan of preparing the aqueous solution of silica, although a stronger solution is obtained by the method first given.

"When a pure aqueous solution of silicic acid prepared as above is allowed to soak into the pores of chalk or dolomite, a process of hardening rapidly occurs, which goes on increasing for several days, whilst, owing to its considerable depth of penetration, and to there being no soluble or efflorescent compounds to be removed, there is every probability that this hard silicious impregnation will afford permanent protection to the stone. We are now actively engaged in investigating the nature of the action which takes place, and already several curious and important results have been made out, from which we are led to anticipate that our experiments will ultimately be rewarded with complete success."

It may not be uninteresting to the practical minds of the gentlemen present, to be informed of some of the uses of this *hydrated silica*. These uses amply show the reason why so many of the prominent European chemists have turned their attention to this subject, and why the English and French governments aid with means and protection the progress in this department of industry.

Some of the applications of hydrated silica.—1. For the preservation of building stones and decaying monuments. The Philadelphia Custom House (an important building in these times of "duties wanted"), and many other buildings in this city, are greatly in need of preservation.

2. For the formation of artificial building and other stones, by admixture of other cheap materials, such as lime, clay, sand, &c., in proper proportions to the liquid silica. Why, I ask, not build our fortifications with the aid of hydrated silica?

3. Wood, by its use, is most effectually rendered fire and water proof, and no decay can enter wood after it has been properly treated. Is it not likely that this article will become of great importance to us for coating ships, bridges, railroad cars, wooden houses, barns, roofs, and fences; for the impregnation of timber used for railroad sleepers, telegraph poles, wharves, &c.? Is our government aware of the value of this liquid?

4. The fresco paintings of Kaulbach, and other German, French, and English painters, have been executed with silicated colors. These paintings will, like the celebrated frescoes at Herculaneum and Pompeii (which chemical analysis shows to have been preserved for so many years by the use of silica colors), withstand the tooth of age. The insides of our public buildings, churches, mansions, and other structures, offer a large field to an army of artists.

5. As hydrated silica, when mixed with a properly prepared mate-

rial, forms a solid and durable marble, susceptible of the most beautiful and variegated coloration, the master-pieces of the art of sculpture *can be cast*, in the same way as the figures now made of plaster of Paris. Tombstones and similar monumental ornaments can thus be placed within the reach of the poorer classes of society. How much more attractive would our squares and public places look if they were tastefully ornamented with fine statuary and bas-reliefs!

6. Pure hydrated silica can, by substitution or otherwise, be made to combine with many organic bases, to form most beautiful and useful materials for gun carriages, wheels, tables, doors, furniture, telegraphic wire covering and insulators, philosophical instruments, parts of all kinds of machinery, hones, grindstones, razor strops, &c.

7. For coating metals to prevent oxidation and electric conduction.

8. The extraction of gold, silver, platina, and other metals, by simply dissolving the silicates and precipitating the metals by their own specific gravity, or by chemical or electrical means, will enable those engaged in this branch of business to procure all the metal from the ore, while, at the same time, they produce a soluble silicate of commercial value.

Many more applications could be enumerated; I think, however, that enough have been given to direct the attention of practical minds to this comparatively new yet highly important subject.

Mr. Fleury exhibited a fine specimen of Colored Marble, made by a patented process purchased by Mr. Waldron J. Cheyney, of this city.

Mr. Fleury also read the following paper on Imitation of Russia Sheet Iron:

The samples of iron, which I now have the pleasure of presenting to the Institute, were made under the patent of Mr. Wm. Riesz from ordinary rolled iron, the original cost of which was 5 cents per pound; the expense of the process was $2\frac{1}{2}$ cents, making the total cost of the iron in its present condition, $7\frac{1}{2}$ cents per pound.

The inventor, who was for a number of years director of a large iron manufacturing establishment in Germany, had made it his particular study to examine theoretically and practically the manufacture of the iron which was imported in large quantities from Russia. By repeated analyses of the iron, and also through noticing its beautiful, smooth, and incorrodible surface (by scraping off the surface from a large number of sheets), he came to the curious conclusion that the Russia iron was not, as he had thought, and as the general impression among iron manufacturers still seems to be, covered by *a film of carburet of iron*, but that the smooth surface consisted of *an atomic accumulation of a peculiar substance, a* NITRIDE *of iron combined with about* 20 *per cent. of carbon:* the nitro-carburetted iron of Fremy.* The quantity of carbon and nitrogen diminished gradually towards the centre, where the iron was nearly pure and very flexible. After years of experiments, he has finally succeeded in producing from ordinary sheet iron the best imitation of Russia sheet iron which, in my opinion, can be made.

* See London Chemical News, "On the Composition of Cast Iron and Steel," by M. E. Fremy, pp. 320, 331, 345, 361, 375. See also last number Journal of the Franklin Institute.

Before explaining the process and the interesting changes that take place, I will mention a few of the most important applications for this iron. The most extensive use of Russia iron is in the manufacture of stoves and stove pipes, where the black modification is preferred. The blue Russia iron we find applied in coverings of locomotive boilers, and other parts of steam machinery. The Massachusetts button manufacturers use black Russia iron for the bases of buttons, safe ornaments, door and other locks.

Large plates can be rolled together and welded to any size, then tempered and converted into steel. It is my opinion that such a plate of $2\frac{1}{2}$ inches in thickness, would offer an equal resistance to the armor plates of the "*Black Warrior*," and I would suggest the use of such plates for the covering of our war vessels. Steel plates could be used for railroad springs, breastplates for soldiers, and for various other purposes. The inventor says that he can make this sheet iron into sword and knife steel. Corrugated sheet iron of this kind is most admirably adapted for the construction of railroad cars, army wagons, transportable rails, and army-boat skeletons, to be carried in pieces, and covered with rubber cloth when used, in a similar manner to life-boats; it may also be used for transportable houses, suitable for our western settlers and others similarly situated.

Though the process is very simple, it requires considerable skill, but once learned by short practice under the guidance of the inventor, it can be carried on in the most regular manner. The iron is cleaned in a sulphuric acid bath, then washed with an alkali and water, and placed in a peculiar mixture described in the patent, which prevents oxidation; it is then rolled with the before-named coating, and, after being re-heated, placed under the hammer to receive the required temper and smoothness.

When the black variety is heated, it becomes dark blue, while the white acquires a beautiful sky blue color. We thus see, that from one and the same iron, four beautifully colored varieties can be obtained.

BIBLIOGRAPHICAL NOTICE.

A Manual of Elementary Geometrical Drawing, involving three dimensions. By S. Edward Warren, C. E., Professor of Descriptive Geometry and Geometrical Drawing in the Rensselaer Polytechnic Institute, Troy, N. Y. New York, John Wiley, 1861. 12mo. pp. 105, plates 16.

This appears to be a valuable work upon a subject the importance of which our mechanics do not yet appear fully to appreciate. The objects of the work are well given in the preface, and proper importance is given to the necessity on the part of the draughtsman of understanding something of the nature of the object which he proposes to represent. The method of the book is good—the style terse and scientific; the definitions precise and easily understood; the illustrations well selected. The book is well printed, and creditable to its publisher.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

NOVEMBER.—The temperature of November was about one degree below the average for the last eleven years, and more than two degrees below the temperature of November, 1860.

The warmest day of the month was the 2d, of which the mean temperature was 58·7°. Rain fell continuously on that day, and the temperature increased until it reached the maximum for the month, about eleven o'clock in the evening, when the thermometer indicated 63½°.

The coldest day was the 25th, with a mean temperature of 35½°. The register thermometer indicated the lowest degree (29) on two days, the 25th and the 27th.

The range of temperature for the month was, consequently, 34½°.

The temperature was at or below the freezing point on seven days of the month.

The greatest change of temperature in the course of a day was 19°, on the 1st; the least was 5°, on the 16th. The average daily oscillation of temperature for the month (13·08°) was very near the average for eleven years, but was a little more than one degree less than for November, 1860.

The greatest mean daily range of temperature was 10½°, and occurred between the 29th and 30th days of the month; the least was half a degree, and occurred between the last day of October and the first of November. The average daily range for the month (4·11°) was 1½° less than the average for eleven years, and about the same amount below that for November, 1860.

The greatest pressure of the atmosphere was 30·109 inches, and was observed at 7 A. M. on the 1st. The minimum pressure was 29·213 inches, and was observed at 2 P. M. on the 6th. The monthly range of pressure was 0·179 of an inch. The average pressure for the month (29·771 ins.) was two-hundredths of an inch less than that for November, 1860, and thirteen-hundredths of an inch less than the average for eleven years, which must be regarded as an anomaly.—According to received theories, the barometric pressure should be increasing, while in fact for this month, it was less than for any other November, during the whole period of observation. The nearest approach to it was 29·795 in November, 1860, and 29·797 in November, 1858.

The greatest mean daily range of atmospheric pressure was 0·513 of an inch, between the 1st and 2d days of the month; the least was 0·045 of an inch, between the 17th and 18th; and the average for the whole month, was 0·179 of an inch, which is very near the average for the whole period of observation.

The force of vapor and dew-point, were less than usual. The force of vapor was greatest (0·523in.) during the rain storm of the 2d of the month, and least (·099 in.) on the 19th.

The relative humidity was greatest on the morning of the 24th, and least on the afternoon of the 19th. The average for the month was very near the general average.

Rain or snow fell on eleven days of the month, to the depth of 4·613 inches, which was 1½ inches less than fell in November, 1860, but about one inch more than the average amount for the last eleven years.

The first *snow* of the season—but a few flakes—was observed on the 16th, but the first in any appreciable amount fell on the evening and night of the 24th. On the morning of the 25th it was half an inch deep on roofs and boards, though there was none on the pavements.

The first *ice* was observed in the streets of the city, on the morning of the 19th, two days earlier than last year.

There were but three days of the month entirely clear, or free from clouds at the hours of observation; and the sky was completely covered with clouds at those hours on four days of the month. The average amount of the sky covered with clouds both for the month of November, 1861, and for the same month for eleven years, was 57 per cent. of the visible sky.

A Comparison of some of the Meteorological Phenomena of NOVEMBER, 1861, *with those of* NOVEMBER, 1860, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Nov. 1861.	Nov. 1860.	Nov. 11 years.
Thermometer.—Highest, . .	63·5°	80°	80°
" Lowest, . .	29·0	16	16
" Daily oscillation,	13·08	14·43	13·36
" Mean daily range,	4·11	5·53	5·62
" Means at 7 A. M.,	39·85	43·30	41·10
" " 2 P. M.,	48·73	50·53	50·34
" " 9 P. M.,	43·25	45·33	44·34
" " for the month,	43·94	46·39	45·26
Barometer.—Highest, . .	30·109 in.	30·305 in	30·661 in.
" Lowest, ...	29·213	29·248	29·117
" Mean daily range, .	·179	·197	·187
" Means at 7 A. M., .	29·793	29·821	29·922
" " 2 P. M., .	29·736	29·773	29 882
" " 9 P. M., .	29·785	29·792	29·908
" " for the month,	29·771	29·795	29·904
Force of Vapor.—Means at 7 A. M.,	·199 in.	·234 in.	·228 in.
" " " 2 P. M.,	·210	·228	·231
" " " 9 P. M.,	·206	·236	·235
" " " for the month,	·205	·233	·232
Relative Humidity.—Means at 7 A. M.,	78 per ct.	76 per ct.	78 per ct.
" " " 2 P. M.,	58	57	59
" " " 9 P. M.,	70	71	74
" " " for the month,	69	68	70
Rain and melted snow, amount	4·613 in.	6·057 in	3·765 in.
No. of days on which rain or snow fell,	11·	12	10·4
Prevailing winds—Times in 1000-ths,	N68°12′W.·324	N81°25′W ·333	N68°1′ W ·254

Autumn.—The Autumn of 1861 was one degree warmer than the Autumn of 1860, and half a degree warmer than the average temperature for the last eleven years. Though these differences are so slight, yet the Autumn just closed (with a temperature of 57·25°) was warmer than any Autumn since that of 1855, of which the mean temperature was 57·87°.

The pressure of the atmosphere, 29·874 inches, was less than that for any Autumn since 1858, when it was exactly the same, and it still continued about five-hundredths of an inch below the average for eleven years.

The force of vapor and relative humidity, were both greater than the average, as will more clearly appear by an examination of the annexed table of comparisons.

The rain was very little less than that which fell in the Autumn of 1860, but it was nearly two inches and three-quarters above the average.

The number of days on which rain or snow fell was 27, five days less than the preceding Autumn, but almost the average for the whole period of observation.

A Comparison of the Autumn *of* 1861, *with that of* 1860, *and of the same season for* eleven *years, at Philadelphia, Pa.*

	Autumn, 1861.	Autumn, 1860.	Autumn, for 11 years.
Thermometer.—Highest, . . .	88°	92°	95°
" Lowest, . .	29	16	16
" Mean daily oscillation,	15·75	16·23	15·39
" " daily range, .	4·60	5·50	5·30
" Means at 7 A. M., .	52·18	51·72	51·65
" " 2 P. M., .	63·36	62·33	62·87
" " 9 P. M., .	56·22	54·99	55·49
" " for the Autumn,	57 25	56·35	56·67
Barometer.—Highest, . . .	30·452 in.	30·313 in.	30·661 in.
" Lowest, . . .	29·213	29·248	29·012
" Mean daily range, . .	·163	·153	·152
" Means at 7 A. M., .	29·897	29·929	29·947
" " 2 P. M., . .	29·847	29·881	29·906
" " 9 P. M., .	29·878	29·909	29·927
" " for the Autumn,	29·874	29·906	29·927
Force of Vapor.—Means at 7 A. M.,	·349 in	·327 in.	·340 in.
" " " 2 P. M., .	·380	·343	·359
" " " 9 P. M.,	·383	·348	·359
" " " for the Autumn,	·371	·339	·353
Relative Humidity.—Means at 7 A. M.,	81 per ct.	78 per ct.	78 per ct.
" " " 2 P. M.,	59	56	57
" " " 9 P. M.,	75	74	74
" " " for the Autumn	72	69	70
Rain and melted snow, amount	13·186 in.	13·649 in.	10·479 in.
No. of days on which rain or snow fell,	27	32	27·1
Prevailing winds—Times in 1000-ths,	N76°25′W·204	S84°34′W ·254	N77°46′W·238

JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

FEBRUARY, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Shot-Proof Vessels—Ericsson's Battery. By ISAAC NEWTON, First Assistant Engineer, U. S. N.

At the present time, while the government is working at the problem of iron-clad vessels, and all thinking citizens are deeply interested and anxiously awaiting the result, an impartial discussion of this very important subject, would not be out of place. It is a matter, too, of the greatest importance financially, as it involves the expenditure of many millions of dollars.

We have delayed too long the construction of iron-clad shot-proof vessels, but before we commence to build them in large numbers, a thorough investigation of the subject is absolutely necessary. Even this delay may, however, prove to be a great advantage, as it gives us the experience of both France and England in building them, as well as the knowledge eliminated by the voluminous papers written by professional men, and published in the principal magazines of England, and also of the discussions, both for and against, between many of her prominent engineers, army and navy officers.

Many of these articles, and also several scientific men, have declared in the most emphatic manner that it would be an act of utter folly to place another wooden war vessel on the stocks, or even to complete those already commenced.

Sir Howard Douglas, one of the first authorities on naval and military matters, and to whom the British navy is greatly indebted for its

present efficiency, has most strenuously opposed all such radical changes. The arguments, facts, and statistics brought to bear by Sir Howard against the use of iron vessels for war purposes, it would be well for every unprejudiced person to examine before forming a hasty conclusion.* In these remarks, Sir Howard does not refer particularly to iron-clad vessels, and his criticisms on that class of vessels are principally as to their efficiency as *cruisers to take place of wooden ships.* Sir Howard revised the last edition of his Naval Gunnery in his *eighty-fifth* year. This venerable and conscientious man has been, on this account, assailed on every side by a host of writers, who, whatever else may have been their ability, had not that thorough scientific knowledge which was necessary to combat the array of facts and arguments he displayed.

The project of clothing vessels with iron armor for the purpose of resisting shot, is not of as recent a date as is generally supposed; it was suggested by Col. Paixhans, better known as the inventor of the Paixhans shell gun, nearly forty years ago. The first examples we have, however, of iron-clad vessels, were those constructed in France and copied by England in the late war with Russia. They were used in conjunction with the immense allied fleet at the attack on Kinburn, and the result, as far as these batteries were concerned, cannot be regarded as settling much in their favor. Douglas states them to have been utter failures; at any rate, they could not carry their own armament, and all their guns were conveyed in transports employed for the purpose.*

The two types of iron-clad vessels upon which we have been accustomed to look, are the French *Gloire* and the English *Warrior.*

These ships differ essentially in many points, but they both possess defects inherent to their mode of construction, which impair their efficiency, either as cruisers or floating batteries, and the idea that such vessels are to take the place, or to perform the duties required of the old-fashioned wooden war vessels, is not for a moment to be tolerated. It is proposed to show, that the principles adopted in the construction of both these vessels are erroneous, and that for the amount of money the *Warrior* cost, eight or nine iron-clad steamers, perfectly impregnable to any projectile she can throw at the shortest ranges, could be constructed, and each one capable of coping with this vaunted frigate. Vessels of the usual form plated with impenetrable armor, will not fulfil either the conditions required of men-of-war, or of impregnable ships. Both the *Gloire* and the *Warrior* may be of special service against a neighboring belligerent power, but not as cruisers, nor as antagonists which we need fear.

Iron-plated shot-proof vessels have their especial function to perform; they can never be any thing more than auxiliaries to a navy and adjuncts to forts for the defence of our harbors, bays, and coasts.

Let us examine the two mail-clad vessels mentioned. The *Gloire* was the first completed. The project, it appears, had long been a favorite one with Napoleon III. She is so overloaded with the enormous weight of her armor, 850 tons, and her armament, that in any thing like a

* Vide Naval Gunnery, and Postscript, by Gen. Sir Howard Douglas, London.

heavy sea, the water not only comes up into her ports, which are but six feet from the surface of the water, but rolls up her sides and over her. Her centre of gravity is so near the metacentre, from the fact that the immense weight of her armor above the water line brings it so much higher above the centre of gravity of the water displaced compared with ordinary vessels, that she is very deficient in stability, and consequently she rolls very deeply; besides, she has no great speed; when loaded for sea and in smooth water, it will probably not be over nine knots.

As a sea-going ship, she is, therefore, an utter failure. The only duty she can perform, and that indifferently, is that of a floating battery.

It may be said, these defects can be obviated in future. In the *Warrior*, in endeavoring to correct these, new ones were created.

Nature will not change her laws: to be successful in mechanics, they must be obeyed.

The English naval architects appreciated these difficulties, and tried to correct them as much as possible, as will be seen by the plans adopted in the construction of the *Warrior*.

This vessel differs from her rival in several important points.

1st. She is constructed entirely of iron, whereas the *Gloire* is a wooden ship iron plated.

2d. Only the central portion of the ship is covered with armor; each end, for a length of nearly one hundred feet, is built in the same manner as is usual with ordinary iron steam ships, the sides being made of plate-iron five-eighths of an inch thick.

3d. Her tonnage is very much greater than that of the *Gloire*.

The reasons for these important differences are obvious. As one of her admirers has well stated, speed had to be attained in combination with a shot-proof hull, and had not the proposal to leave the ends of the ship uncased been adopted, this combination would have been practically impossible, except with far greater dimensions than even the *Warrior's*.

Her constructors, as has been remarked, appreciated at once the defects of the *Gloire*, and endeavored to obviate, or at least to ameliorate them as much as was possible, in the construction of the *Warrior*. They were determined at any rate to build a ship which would perform more satisfactorily at sea; and they were required to excel their rival in speed. The *Gloire* was deficient in stability; she would be a mere log in a sea way; her guns were but six feet from the water, and could not be used at all, except in comparatively calm weather. Therefore, to overcome these difficulties, they build a larger ship, and to make assurance doubly sure (as regards sea qualities and speed), they only cover seven-thirteenths of her length with armor. Even the increased size alone was a very great advantage in assisting them to accomplish these ends. This is apparent when it is remembered that the area to be covered by iron armor increases as the square, while the capacity to carry it, or, in other words, the displacement of the vessel, increases as the cube of the dimensions.

The part protected by shot-proof armor does not, in this ship, much exceed the length occupied by engines and boilers.

Again, her ends being free from the enormous weight of shot-proof armor, they were enabled to make them much finer than otherwise; and almost for the first time in the construction of a war vessel, the armament was the last thing considered; it was ship first, and *battery* last.

She is, according to the published statements, a forty-eight gun ship, of which but thirty-six are *protected* by shot-proof armor.—These guns are the 68-pounder of ninety-five hundredweight; it has been stated, however, that some of these may give place to 100-pounder Armstrong rifled guns.

It has been perceived that both extremities of the *Warrior* are exposed to destruction; that only the central part is pretended to be shot-proof. The masts, sails, and rigging, are liable to be shot away, and strew the decks, to drag over the sides and entangle the screw, preventing it from being used. The bow, together with the rigging it supports, and the stern, which not only contains the officers' quarters, but also supports those vital parts, the *screw* and *rudder*, will be exposed to destruction by the enemy's shot, and most certainly they will be the parts aimed at.

Although when both her extremities are shattered and filled with water, she may not sink, her situation at sea would be one of extreme danger, or if attacking a fortification, equivalent to a capture. That the mistake of leaving these ends unprotected is acknowledged, every candid person will admit, when it is stated that the iron-clad vessels now being built in England, are to be plated from stem to stern, the beautiful overhanging prow and the round ornamental stern, which we have all considered as essential features of a man-of-war, are abandoned; they begin to understand now the defects of the *Warrior* as well as they did those of the *Gloire*, and appreciate thoroughly the inefficiency of the enormous and extravagant vessel just completed. In the new vessels, the bow and stern will be nearly alike; experience has taught them the difficulty, if not the almost impossibility of plating vessels of the ordinary form with shot-proof armor from stem to stern; they are driven by necessity to a more simple shape. Still, they are producing vessels which are comparatively useless for many of the purposes intended, as from their great draft of water, there are few harbors which they can enter with safety. The immense weight of their armor, owing to the large amount of *surface* to be protected, is utterly incompatible with speed, and even their batteries are not so *very* formidable.

There is every reason to believe that even the *Warrior* herself, with her fine uncased ends, can never at sea under steam, attain a speed of over eleven knots. It must be borne in mind, when reading of the performances of steam vessels, that the speed usually credited to them, is that which they have on a trial trip attained in some smooth harbor for a measured mile, under circumstances which are seldom met with at sea, and when their boilers are new and perfectly clean.

Now what function can these colossal and expensive structures perform? Can they demolish our granite casemated forts, enter our harbors, and shell our cities, even if a fleet of them should succeed in crossing the Atlantic? No, they cannot; from their great draft of water they cannot succeed in approaching within breaching range of most of our forts, and even if the object to be attained should not be to reduce but to run by them for ulterior purposes, they can be stopped, yes, destroyed, if the attempt should be made; provided we use the means in our power; that is, if the forts are provided, as the U. S. Engineers insist, with the heaviest *successful* ordnance known, the fifteen-inch gun, cast after the method of Capt. Rodman, U. S. A.,* a shot from which would literally crush in their sides as easily as a segar-box, assisted by *shot-proof gunboats*, also equipped with the heaviest ordnance.

Military science should seek rather to counteract than to imitate, and most thoroughly has it been done in this case. This is no speculation; the 15-inch gun has been made and used successfully, and it is asserted by no less an authority than Major Barnard himself, "that a gun of even twenty inches calibre can probably be made, and not only *made* but used. Will they prove such formidable antagonists to our wooden ships of greater speed and heavier battery? We may successfully counteract their comparative impregnability with *speed* and a judicious arrangement of battery. Speed is a point which now nearly all naval officers acknowledge to be of paramount importance, a surrender of which cannot under any circumstances be permitted. Steam no longer plays a second part; this condition is reversed, and sails are now considered to be auxiliary.

In all vessels now being built for the navy, speed under steam is a *sine qua non;* the hallucination of *auxiliary steam power* has been exploded, and already steps have been taken to greatly increase the speed of our large screw frigates. The arguments which the writer in the *Cornhill Magazine* for Feb., 1861, uses to prove the great advantages of the *Warrior* over the *Gloire* would apply, according to his reasoning, almost as forcibly to a *swift* well armed screw frigate as they do to the *Warrior* herself. It is not possible, other things being equal, for an iron-clad shot-proof frigate, loaded as she is with both armor and battery, to be equal in speed to a wooden frigate burthened only with her battery, and even a heavier one.

It is worse than useless for us to waste millions of dollars on *Gloires* and *Warriors*. We perceive and understand fully the functions which shot-proof iron-clad vessels are destined to perform, namely, as *auxiliaries* to our navy and fortifications, in the defence of our harbors, bays, coasts, and adjacent waters, from any attack which may be made by any fleet, no matter how large. The more we examine the question the more we are convinced that the whole matter of iron-clad vessels, in both France and England, has been a game of "brag;" they have built vessels useful only to intimidate each other, formidable to no one else; indeed, it would not be a great exaggeration to say that they

* For a description of this gun, see "Notes on Sea Coast Defence," by Major Barnard, U. S. A.

were built more with a view to their own safety than to be terrible to their enemies.

The excitement created in England by the appearance of this solitary vessel, and the announcement that some more were to be built, is hardly to be credited. Think of the millions that are now being spent there upon both forts and iron-cased steamers; they are not willing to substitute entirely a perishable for an imperishable defence, and if the skill and judgment of the U. S. Engineers and the system of sea coast defence inaugurated nearly forty years since needs an endorsement, it has it here.

This paper could not be regarded as complete if it omitted to mention that notable structure, the Stevens Battery, which has become almost a household word. Probably no enterprise in which the government has ever been interested has attracted so much attention and caused so much speculation; this no doubt has been occasioned principally by the impenetrable mystery which has surrounded it, and the strict secresy with which those parts already constructed have been built; even the government itself had no thorough knowledge of what was going on.

Now that the veil has been lifted by the Board of Commissioners appointed by the Secretary of the Navy to examine and report upon it, curiosity is at least satisfied. This Board was composed of Commodores Stringham and Inman, Captain Dornin, and Chief Engineer Stimers, U. S. N.,and Professor Henry, of the Smithsonian Institute. This latter gentleman made a minority report.

However much credit is due to Mr. Stevens for priority in suggesting the feasibility of constructing shot-proof vessels, by coating them with iron, the present structure and the various plans proposed for its completion have been the work of the last few years.

The Battery, as far as completed, consists of a long, slender, iron vessel, without decks, the entire central portion filled with engines and boilers. The vessel is provided with two independent screws, which by revolving them in opposite directions, will cause the ship to turn around in nearly her own length.

It was the intention of her projector, by supplying her with immense power and by giving her the sharpest ends ever constructed, to produce a speed unrivalled in the history of navigation.

As is already well known, the Board reported against the completion of the vessel upon the plans proposed. This report is exceedingly thorough and is very much in detail; at the same time it must be said that it is quite impartial and just. The description of the vessel and the plans proposed to complete her, which occupy the first part of the report, were warmly commended by the parties themselves, on account of its perfect accuracy. So the correctness of the criticisms which form the latter part of it, and the conclusion which condemns the completion upon the plans proposed, may be judged accordingly. These plans must have been of very recent origin, as they differ materially from those advanced by her projector, R. L. Stevens, Esq., deceased.

It was the intention of her projector to have vertical sides above water, pierced with gun ports; the inclined armor and the plan of having the guns exposed *en barbette* on top of the vessel appears to be of very recent date.

The principal points upon which the Board condemned it, form radical parts of the entire plan, and which cannot be obviated without entirely reconstructing those parts already completed, (which are in fact nothing more than the hull of an unusually sharp iron steamer, with the steam machinery,) are, first, Great deficiency in strength, both as regards sea-going qualities and the ability to support the armor proposed. Second, The plan of mounting the guns *en barbette*, with nothing whatever to screen them from the view of the enemy, and depending upon their immense size to protect them from destruction when struck by shot. Experiments tried at Woolwich, England, in 1857, prove that masses of cast iron nearly as large as the 15-inch gun were entirely destroyed by shot from the 68-pounder gun. Third, That the vessel would not be in all parts and at all times shot-proof.

These objections involve many important minor ones, which from the space allotted to this paper cannot be enumerated.

One is, however, that the fact of having the guns exposed entails the necessity, for the protection of the gunners, of having them manipulated, both as regards loading and training, by complicated machinery placed below the deck upon which they are mounted, only one man to each gun to aim and fire it being on deck in time of action.

Whatever may be the theoretical advantage of the plan of partially sinking the vessel to secure the additional protection of the water, in time of action, it is impracticable, for reasons well pointed out by the Board; besides, it would be far better to make the vessel perfectly shot-proof, without depending on such a plan for her protection when in presence of the enemy; indeed, there might be times when the weather would preclude this partially sinking.

Congress have acted very judiciously on the subject of iron-clad vessels, evidently unwilling to vote immense sums of money to be expended on projects of doubtful success. At the special session last summer, however, an act was passed authorizing the Secretary of the Navy to advertise for proposals to construct one or more iron-clad shot-proof vessels—each one proposing to furnish his own plans; it was also provided that these plans should be approved of by three commanding officers of the navy, and a board was appointed for this purpose, consisting of Commodores Smith and Paulding, and Captain Davis. $ 1,500,000 was appropriated to build such as were approved of. Three were selected, all different from each other.

Among these was one presented by the eminent engineer, Ericsson. In designing this vessel he displayed that thorough knowledge of mechanical philosophy which is the most strongly marked trait of his character, and which has not probably been possessed to so great an extent by any engineer since the days of Watt; this same knowledge he so successfully brought to bear upon the introduction of the screw propeller, constructing one long before the tedious experiments

upon this subject tried by England and France had been performed, and which only proved that the principles adopted by him were correct.

Every American will remember with pride the old frigate *Princeton*, the first screw steamship of war with her machinery placed entirely below the water-line, out of the reach of shot; the first which burned anthracite coal, avoiding that dense smoke which even now reveals plainly for miles the position of all foreign war steamers; the first provided with a telescopic funnel, which could be lowered out of the way of the sails; the first that used blowers, thus making the supply of steam perfectly independent of the smoke pipe; in fact, the first really successful application of the screw to vessels of war. She was provided with *direct-acting engines*, which worked beautifully for years. Ericsson at an early day saw their advantages, and was the first who coupled the screw directly to the engines. This vessel, as almost every one knows, was designed by Ericsson over twenty years ago.

So when the problem of shot-proof vessels arose, he perceived at once the duties required of such a vessel, and, instead of proceeding as his predecessors have done, in loading down vessels of the *ordinary form* with the immense weight of shot-proof armor required to entirely cover them, he adopted at once the shape which gives the greatest possible buoyancy with the smallest area of target. A broad, flat-bottomed vessel, with perpendicular sides and regular pointed ends, requires but little depth to displace a sufficient quantity of water to buoy itself up, loaded with shot-proof armor on its sides, and a bomb-proof deck, upon which is placed a shot-proof revolving turret, armed with two of the heaviest guns.

This is what is termed the upper vessel; its length is 172 feet, breadth 41 feet, and depth 5 feet. The sides of this vessel are formed first of plate iron $\frac{1}{2}$-inch thick, next to which is fastened solid oak 26 inches thick; this oak then receives the shot-proof armor of rolled iron in five laminæ of 1 inch thick each. The deck, which is bomb-proof, is composed first of white oak beams 10 inches square, and 26 inches apart between the faces, upon which is placed planking 7 inches in thickness, and finally the whole is covered with a layer of rolled iron 1 inch thick.

The bottoms of these beams are on a level with the water, so that the armor above water has a wooden backing of 41 feet. It will be seen that, instead of having the compound curves and great surface of an ordinary modeled vessel to plate, and which in fact are almost utterly impossible to cover properly, every part is straight, or has curves in one direction only, so the heavy armor can be applied with great facility.

To appreciate this great advantage of *simplicity of form*, it is only necessary to see the rapidity with which the heavy plates are fitted and secured.

This upper vessel will be 3 feet 6 inches under water, thus leaving but 1 foot 6 inches above the surface. Now, if this vessel which we have described could be anchored in any desired position, we would

have all that is required. Therefore, to give such a vessel the space required to carry her steam machinery, fuel, stores, and the quarters for the officers and men, it is only necessary to secure beneath it a vessel of ordinary strength.

This is what is termed the lower vessel; it is 124 feet long, 34 feet in breadth at its junction with the upper one, 18 feet at the bottom, and 6 feet 6 inches deep.

In speaking of these as the upper and lower vessels, it must not be supposed that they are built separately; they make together one vessel; it is only as regards the form of the vessel that they can be spoken of as two.

It will also be perceived that the lower vessel is much narrower than the upper one at their junction, and that its sides are very sloping; this is done so that if the enemy's projectile, such as the Whitworth bolt, should possibly pass below the upper shot-proof vessel, the sides of the lower one would be struck at such an acute angle that no damage could occur. The same provision is also made at both the bow and stern.

The upper vessel projects far enough over the bow of the lower one to contain a circular aperture, in which the anchor is hoisted by a capstan in the bow of the lower vessel; at the stern it also projects far enough to thoroughly protect the rudder and screw.

There will be two blowers, drawing their supply of air through bomb-proof gratings in the deck above; one to create a draft for the boilers, and the other to ventilate the ship. The smoke and gases from the boilers pass through bomb-proof gratings in the deck.

The entire vessel is divided near the centre by a strong wrought iron bulkhead, on the after side of which are the steam machinery and coal, and forward the quarters for the officers and men (which are quite comfortable and spacious), and the store rooms, magazines, &c.

The revolving turret is composed of a rolled iron skeleton 1 inch in thickness, to which is riveted and bolted eight laminæ of rolled plates each 1 inch thick. These plates are very accurately fitted up, the seams are vertical, and the joints so arranged as not to come in the same line. The top is made bomb-proof by being covered with a bomb-proof roof placed six inches down in the cylinder.

The diameter of the interior of the turret is 20 feet, and the height from the deck 9 feet. Within this turret are two 11-inch Dahlgren smooth-bore guns, but 15-inch guns could be mounted in it.

Two enormous wrought iron pendulums are so arranged that when the gun recoils they will swing by and effectually close the portholes. The general reader may ask, Why are not there those terrible rifle guns,* about which so much has been said? The reason simply is, that spherical shot are much more efficient at short ranges than rifled ones are at any range, and as this vessel is shot-proof, she will engage the enemy at a distance of from 300 to 400 yards.

* Notwithstanding how much we have heard of Armstrong and other rifled guns, the Dahlgren rifled 150-pounder, of 16,000 pounds weight, from its extreme simplicity and beauty of workmanship, is far ahead of any species of rifled gun ever yet constructed; it is cast without trunnions or cascable, to avoid the strain caused by protuberances in castings, without an angle to mar its beautifully curved outline. To those who have a mechanical eye, and can appreciate simplicity, this gun will be viewed with the greatest admiration.

Her draft of water is ten feet. It is expected that she will have a speed of eight knots. She is not intended as a cruiser, but can proceed safely by sea to any part of our coast during the roughest weather. The bomb-proof gratings for the furnaces and blowers at such times will be protected by suitable pipes, to prevent the water from entering if it should come on the deck.

If desirable in those which may hereafter be built, a greater speed can be attained by simply giving more steam power; but it is thought the speed she will possess is ample for all purposes for which this one is intended.

Her cost complete will be $ 275,000, or about one-eighth the cost of the *Warrior*. Imagine the *Warrior* surrounded by eight such vessels, perfectly shot-proof, sticking close to her, and their 11-inch wrought iron shot smashing in her sides!

The weight of the vessel complete with stores, ammunition, and coal, will be about 1000 tons, the armor alone of the *Warrior* weighs 1300 tons.

This will in all probability be the first sea-going iron-clad shot-proof vessel ever usd in actual warfare. This is the only plan ever yet promulgated which thoroughly protects every vital part of the vessel itself and every body within it.

It will be seen that thus far we have lost nothing by the delay, which has brought forth a form of vessel complying so perfectly with the necessities which are imposed by the heavy armament necessary in obtaining impregnability. We think we have now the principle required; let us proceed cautiously, and correct in those to be built in future any slight defects which this may exhibit themselves in actual use.

New York, January 15, 1862.

On the Induration and Preservation of Stone. By Messrs. Bartlett Brothers and Co., Camden Town.

From the London Chemical News, No. 101.

Amongst the many efforts to effect the preservation of stone, we respectfully ask you to chronicle our own in the pages of your journal. It would ill become us to disparage other processes, or attempt to laud our own invention, in your columns. We propose, therefore, to confine ourselves to a full description of the invention, the materials we use to accomplish our end, and the behavior of these materials separately and in combination. Enough has been said in this journal to show, from logical and chemical reasoning, that silica must form a principal feature in all efforts to produce an eligible material for purposes of induration. Silica, then, is the principal material in our process, and that in the form of silicate of potash. Of this material in itself we need say but little; but, lest silicate of soda and potash should here be deemed synonymous, we would anticipate our remarks by saying that in this process they are by no means identical, the silicate of soda producing results both unsatisfactory and valueless.

The second material is the aluminate of potash. Of this, in the form of an aqueous solution, we find it stated by all chemical authorities to the present time, that it precipitates an hydrate of alumina, difficultly soluble in excess of the precipitant; and thus we found it behave after forty-eight hours, precipitating most bulkily in heavy solutions, and as much so in proportion in light specific gravities. We need not say how valueless was such a solution commercially, nor tell the difficulties attending the discovery of a simple remedy, so simple as the determination of the particular specific gravity at which it would not precipitate. The behavior of the aluminate with water is remarkable, seeing that one atom of alumina held in perfect solution by say three atoms of water, should be precipitated by the addition of a fourth, or by the withdrawal of one of the three atoms. Such facts we leave to the investigation of those who may be pleased to pursue them further. Suffice it to say, then, that the aluminate used is prepared from a fused compound of alumina and potash, which product, being highly deliquescent, is easily soluble in water, and so nearly neutral as to contain in its best form of manufacture but two per cent. of free potash.

In the combination of silicate of potash and this aluminate of potash consists the process, the consideration of which affords some most interesting details. When silicate of potash, sp. gr. 1·250, and aluminate of potash, sp. gr. 1·200, are mixed together, an instantaneous decomposition takes place, and the result is a solid mass, consisting of silicate of alumina and some free potash. This hardens with extraordinary rapidity, and is a most beautiful example of the great affinity of silica for alumina. But take a solution of a lighter specific gravity, and we find that decomposition does not instantaneously take place. On the contrary, the liquidity of the two solutions in combination is retained for a time, only, however, proportioned to the quantity of water with which it is diluted. Thus, a specific gravity of 1·150 will last as a solution ten hours, while at 1·200 it solidifies immediately. The cause of this arrest of the decomposition—if, indeed, it is arrested—and the peculiar part the water plays in this interchange of elements, will yield a field of interesting inquiry. With the results, however, we have now more immediately to deal; and

Firstly, the time so necessary for manipulation is given in the use of these materials, which in themselves secure an insoluble product by their mutual decomposition.

Secondly, that the agent and re-agent being mixed in one solution, there can be no fear of the one or the other being in excess or unneutralized, as in the use of acid or second solutions.

Thirdly, the product resulting from this combination of silicate of potash and alumina is insoluble in dilute sulphuric and hydrochloric acids.

And, lastly, if Ansten, Bath, and Caen stone or chalk be pounded, this product will recombine them, thus showing that its chemical affinities are in favor of the material with which it is proposed to impregnate the stone.

Finally, in the works of Füch, and the *brochures* of Kühlmann, the foreshadowing of this process may be seen; and in the Report of the Commission appointed to investigate the causes of the decay of the Houses of Parliament, there are mentioned, though not in conjunction, the very materials proposed to be used by this process. We trust that our researches in this direction may prove so successful as to benefit the public at large, and afford its quota of like satisfaction to ourselves.

The Tunnel through Mount Cenis.

From the London Mechanics' Magazine, September, 1861.

A letter in the *Patrie* describes the progress of this great work. The cutting of the tunnel advances day and night with a regularity which excites the admiration of engineers. At the commencement of this great enterprise only the pickaxe and blasting were employed, but since the machines invented by MM. Grattone and Sommellier were brought into use, the cutting of the rock has been carried on with remarkable celerity. The machines, which are worked by compressed air, are very ingenious; they are each of 250 horse power, and act simultaneously on both sides of the mountain. They set in motion different instruments of great power, which operate in any direction that may be required. The section of the tunnel is about 60 metres, and when the cutting was commenced only 12 men could, from the limited space, be occupied at each end, the work they did being only 40 centimetres (about 16 inches) per day; but the machines employ a force equal to 2500 men, and cut out daily two metres—that is, one at each end. In a few months arrangements will be made for making the men employed relieve each other every eight hours, and an electric light will be established; and then the extraction of rock will be three metres per day. The tunnel will be 12 kilometres ($7\frac{1}{2}$ miles) in length. It is 1330 metres above the level of the sea, and 1060 below the summit of Mount Cenis. It will gradually rise $\frac{1}{2}$ per 1000 to the centre, descending from that point towards Piedmont on the other. In the centre of the way a small canal has been formed for carrying off the waters which filter through the rock. Every fortnight an examination is made for the purpose of ascertaining the direction of the tunnel and level of the roadway, instruments of great precision being employed in the operation. Thus far the cutting on both sides of the mountain has been found to coincide exactly. The rock is easily penetrated by the machines. When holes of from 40 to 60 centimetres (16 to 23 inches) have been bored, they are filled with gunpowder; the workmen retire to a distance of about 100 metres, and strong doors in iron are closed to prevent fragments of the rock from flying out. Then the mine is fired, and masses of rock are heard to strike against the doors. Afterwards a current of compressed air is driven into the tunnel to expel the smoke, so as to allow the workmen to enter. The removing of the fragments of rock is effected in the way employed on the cuttings of railways, and the machines are again set in motion.

For the Journal of the Franklin Institute.

Experimental Proofs of the Formulæ for several Cases of the Deflection of Solids. By James B. Francis, Civ. Eng.

Engineers are seldom content, in important cases, to rely upon formulæ founded mainly, or even partially, on theoretical considerations, unless they have been tested either by previous practical use, or by experiments made for the purpose. The rules for computing the strength of materials are particularly important to the profession, and great attention has been given of late to the experimental determination of those required for the ordinary questions that arise in practice. With only a slight departure, however, from the ordinary cases, there is seldom any guide excepting mathematical deduction; this is necessarily founded on certain definite assumptions as to the properties of materials, and it is well understood that these assumptions are not strictly correct, and that, consequently, the deductions have not the character of mathematical truths.

Navier, the celebrated Professor at the Polytechnic School in Paris, is one of the most accurate writers on the theory of the strength of materials. In the first part of his *Résumé des Leçons sur l'Application de la Mécanique*, he gives the formulæ for the usual cases, and also for a variety of other cases, some of them very interesting, and only needing the confirmation of experiment to make them useful to engineers. The writer having had occasion to apply some of these formulæ, tested them experimentally, and believing that the results may serve to give confidence in their application to others as well as himself, he has prepared the following account of them:

Formulæ for the deflection of prismatic beams or shafts of wrought iron, supported at each end.

Let W = weight supported at the middle point between the supports, in pounds.
W' = weight uniformly distributed between supports, in pounds.
l = distance between the supports, in inches.
a = breadth of a rectangular beam, "
b = depth " " "
d = diameter of a cylindrical shaft, "
δ = deflection at the middle point between supports, in inches.
π = ratio between the diameter and circumference of a circle.
E = a constant for the same kind of material.

In the formulæ as given by Navier, E has a value eight times that required in Barlow's formulæ (Barlow on the Strength of Materials, 1837). Barlow's scale is adopted in this paper, and also the corresponding co-efficients.

The following formulæ are well established:—

For rectangular beams, with the weight at the middle point between the supports,

$$\delta = \frac{l^3 \text{W}}{32\, a\, b^3 \text{E}}. \qquad . \qquad . \qquad . \quad (1)$$

For rectangular beams, with the weight uniformly distributed,

$$\delta = \frac{5}{8} \times \frac{l^3 \text{W}'}{32\, a\, b^3 \text{E}}. \qquad . \qquad . \quad (2)$$

For cylindrical shafts, with the weight at the middle point between the supports,

$$\delta = \frac{l^3 \text{W}}{6 \pi d^4 \text{E}}. \qquad . \qquad . \qquad . \quad (3)$$

For cylindrical shafts, with the weight uniformly distributed,

$$\delta = \frac{5}{8} \times \frac{l^3 \text{W}'}{6 \pi d^4 \text{E}}. \qquad . \qquad . \quad (4)$$

The value of E is to be determined by experiment. I take for the purpose, four experiments on a large scale, given in the Appendix to the report made to the British government by the Commissioners appointed to inquire into the application of iron to railway structures, 1849, pages 39 to 46.

In the following table, the value of E is deduced from each experiment, by means of formula (1).

The distance between the supports was 162 inches.

Number of Bar.	Dimensions of Bar. Depth in inches. b.	Breadth in inches. a.	Weight applied at the middle, producing a deflection of one inch. Pounds. W.	Value of E.
1	1·515	5·523	497·87	3,444,278
2	1·027	5·510	157·27	3,500,888
3	1·522	5·018	464·41	3,487,562
4	1·026	5·050	145·22	3,537,429
	Mean value of E, ...			3,492,539

Adopting this mean value of E, we can deduce from formulæ (3) and (4), the following formulæ for the deflection of cylindrical shafts.

With a weight at the middle point between the supports,

$$\delta = 0{\cdot}000\ 000\ 015\ 190 \frac{l^3 \text{W}}{d^4}, \qquad . \qquad . \quad (5)$$

and with the weight uniformly distributed,

$$\delta = 0{\cdot}000\ 000\ 009\ 494 \frac{l^3 \text{W}'}{d^4}. \qquad . \qquad . \quad (6)$$

If the weight uniformly distributed is only the weight of the shaft itself, we may substitute for w' its value in terms of l and d.

The weight of a cubic inch of wrought iron being 0·281 pounds,

$$w' = 0{\cdot}281 \times \tfrac{1}{4} \pi d^2 l;$$

substituting this value in (6), we have

$$\delta = 0{\cdot}000\,000\,002\,095 \frac{l^4}{d^2}. \qquad (7)$$

To test formulæ (5) and (7), a shaft was selected from a number just finished at the Lowell Machine Shop, and its deflection from a weight at the middle, and also from its own weight alone, was measured and compared with the deflections computed by the formulæ.

The shaft was 16 feet long, and exactly 2 inches in diameter, turned and polished, and without any appreciable irregularity in the part between the bearings.

A substantial frame was erected, having iron bearings to support the shaft, 179·976 inches apart in the clear. A straight edge of white pine, $14\frac{3}{8} \times 2\frac{1}{8}$ inches, was fastened to the posts carrying the bearings, above the shaft; one side of it being in the same vertical plane as the axis of the shaft.

To ascertain the deflection, measurements were taken from the bottom of the straight edge to the top of the shaft over each bearing, as well as at the middle point between the bearings; no appreciable change took place at the bearings, which indicated that the apparatus was stable.

EXPERIMENT 1.—Deflection from a weight applied at the middle point between the bearings.

Weight,	26·08 lbs.	
Observed deflection,		0·1500 inches.
Deflection computed by formula (5),		0·1443 "
Difference,		0·0057 "

EXPERIMENT 2.—Deflection at the middle point between the supports, from the weight of the shaft alone.

This experiment required some precautions and corrections not necessary in the first experiment, where the *increased* deflection due to the weight in the middle was all that was required, while in this, the *total* deflection was required.

The shaft might not have been straight when unstrained. To eliminate any error from this source, the apparent deflection was measured four times, the shaft being turned over a quadrant at each measurement after the first; the mean of the four measurements was taken.

The straight edge was made with great care, and was assumed to be straight when unstrained, but it evidently would deflect a little from its own weight when in position. To ascertain the correction, its weight between its supports was ascertained, and the amount it deflected when a certain weight was applied at its middle point was measured; from these data, its deflection from its own weight alone was found to

be 0·0102 inches; which correction should be added to the observed deflection of the shaft.

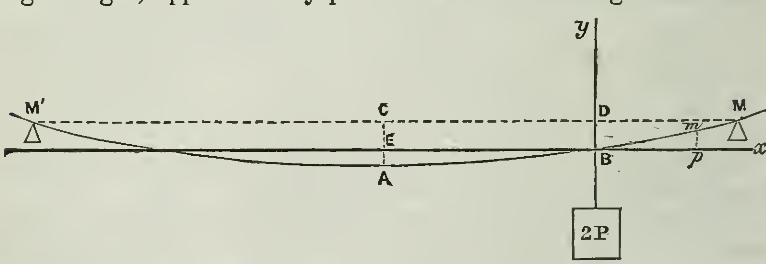
Six inches in length of the shaft, weighing about 5·3 pounds, projected over each bearing; this diminished the deflection at the middle point by an amount equal to that which would be produced by the weight $\frac{5 \cdot 3 \times 3 \times 2}{89 \cdot 988} = 0 \cdot 353$ pounds applied at that point. By formula (5), this deflection would be 0·0020 inch., and this correction must also be added to the observed deflection.

The mean observed deflection, was . .	0·5340 inches.
Correction for deflection of straight edge, .	0·0102 "
" effect of parts of shaft that projected over the bearings, . .	0·0020 "
Corrected observed deflection, . .	0·5462 "
Deflection computed by formula (7), . .	0·5495 "
Difference, . .	0·0033 "

The agreement between the computed and observed results is so near, that they may be considered identical; consequently, formulæ (5) and (7), as well as (1), (3), (4), and (6), from which they have been deduced, may be considered as satisfactorily tested.

Deflection of a rectangular prismatic beam, at the middle point between the bearings, caused by weights applied at one or more points.

Navier gives the following formulæ for the deflection, caused by a single weight, applied at any point between the bearings:



Let a = C M = C M′ = half the distance between the supports.
z = the distance C D.
x = the abscissa B p.
y = the ordinate $m\ p$.
f = B D = the deflection at the point at which the weight is applied.
P = half the weight applied at the point B, in pounds.
b = the width of the beam.
c = the depth " "
E = a constant for the same material, according to Barlow's scale.
$e = \frac{2}{3}\, \text{E}\, b\, c^3$.

The inch being the unit of length.

$$f = \frac{\text{P}}{e} \cdot \frac{(a^2 - z^2)^2}{3\,a} \quad . \quad . \qquad (8)$$

Referring to rectangular co-ordinates, the point B being the origin, the equation of the part of the curve B M is

$$y = \frac{\text{P}}{e} \cdot \frac{a + z}{a} \left[\tfrac{2}{3}\,(a - z)\,z\,x + \tfrac{1}{2}\,(a - z)\,x^2 - \tfrac{1}{6}\,x^3 \right] \quad . \qquad (9)$$

and of the part B M′,

$$y = \frac{\text{P}}{e} \cdot \frac{a - z}{a} \left[- \tfrac{2}{3}(a + z)\,z\,x + \tfrac{1}{2}(a + z)\,x^2 - \tfrac{1}{6}\,x^3 \right] \quad . \qquad (10)$$

If the total deflection is small, it is evident that the deflections caused by several weights, applied at different points, may be computed separately, and the sum will be the total deflection.

To test these formulæ, a piece of white pine (*Pinus Strobus*) was selected; it was straight grained, free from all apparent defects, and thoroughly seasoned, having been kyanized seven years previously, and kept under cover during the interval. It was carefully worked to a regular form, and the exact dimensions were—

Distance between bearings	=	$2\,a$	=	120·024	inches.
Width	=	b	=	3·876	"
Depth	=	c	=	3·878	"

A substantial frame was erected, which carried two iron bearings and a straight edge. Plates of iron were placed between the bearings and the beam, to prevent the former from indenting the latter. This, however, did not entirely prevent the pressure from lowering the beam at the ends, and at each observation measures were taken over each bearing, as well as at the middle, and the proper correction made.

To find the value of the constant E for this particular piece of wood, a weight of 100·03 pounds was applied at the middle point. Twenty-four hours after the weight was applied, the deflection produced by it was found to be 0·188 inch.

The value of E can be found from this experiment by formula (1), from which we deduce

$$\text{E} = \frac{l^3\,\text{W}}{32\,a\,b^3\,\delta}.$$

Substituting the data furnished by the experiment, we find

$$\text{E} = 127{,}180.$$

Four weights of 50,133 pounds each, were then applied at different points on the beam, viz: one on each side of the middle and 20·004 inches from it, and one on each side of the middle and 40·008 inches from it; the weight of 100·03 pounds remaining at the middle.

When the weight of 100·03 pounds had been on 48 hours, and the other four weights 24 hours, the deflection at the middle point was found to be . . .	0·432	inch.
In another 24 hours it had increased to .	0·443	"
And in $10\frac{1}{2}$ months it had increased to . .	0·582	"

The following table contains the data and computed results for each weight. The deflection at the middle point, only, having to be computed by formulæ (9) or (10), it can be much simplified, by recollecting that for this point $x = z$.

Number of the weight.	Weight Pounds. 2 P.	Distance of the weight from the middle point between the bearings. Inches. z.	Deflection at the point of application of the weight. f.	Deflection at the middle point, below the axis of x. y.	Whole deflection at the middle point from this weight. Inches.
1	50·133	40·008	0·02908	0·01629	0·04537
2	50·133	20·004	0·07445	0·00582	0·08027
3	100·030	0·	0·18800	0·	0·18800
4	50·133	20·004	0·07445	0 00582	0·08027
5	50·133	40·008	0·02908	0·01629	0·04537
Total computed deflection at middle point, . . .					0·43928

It should be borne in mind that this result depends upon the value of E, which was determined from an experiment in which the weight had been applied 24 hours. As the deflection of wood depends, in some measure, on the length of time the weight has been applied, which is not taken into account in the formulæ, the comparison can be properly made, only, with an experiment in which the weight had been applied about 24 hours also. In the test experiment, when this condition was most nearly complied with, the observed deflection was 0·432 inch, which differs very little from the total computed deflection in the above table.

Formulæ (8), (9), and (10), were also tested by the deflection of a bar of iron, placed in the frame last described.

The bar was purchased as "common English iron," and marked "L. W. refined." Its dimensions were—

Distance between bearings, . .	120·024 inches.
Width, . . .	1·238 "
Depth, . . .	1·248 "

To find the value of E for this particular bar, a weight of 121·75 pounds was applied at the middle point between the bearings; this caused a deflection of 0·7812 inches, which gives E = 3,499,425.

The weight of 121·75 pounds was then moved to a point 20·004 inches from the middle.

The observed deflection at the middle was then .	0·6664 inch.
The formulæ give . .	0·6655 "
Difference, . .	0·0009 "

The same weight was then moved to a point 40·008 inches from the middle.

The observed deflection at the middle was then .	0·3744 inch.
The formulæ give . .	0·3761 "
Difference, . .	0·0017 "

The weight at the last mentioned point was then increased to 196·87 pounds.

The observed deflection at the middle was then	.	0·6024 inch.
The formulæ give	. .	0·6082 "
Difference,	. .	0·0058 "

These differences are all very small; that in the last trial, which is the greatest, could scarcely be detected with the apparatus used, although the weight was applied at a distance from one of the bearings, equal to only one-sixth of the whole distance between the bearings, and the weight was equal to about one-fifth of the breaking weight, if applied at the middle of the bar.

The measures of the observed deflections in the preceding experiments were made with fine graduated ivory scales; the two final decimals given, result principally from taking means of several measurements.

[Read before the British Association at Manchester.]

Experiments on the Gauging of Water by Triangular Notches. By J. Thomson, A. M., Prof. Civ. Eng., Queen's College, Belfast.

From the Lond. Civ. Eng. and Arch. Journal, December, 1861.

In 1858, I presented to the Association an interim report on the new method which I had proposed for the gauging of flowing water by triangular (or V-shaped) notches, in vertical plates instead of the rectangular notches with level bottom and upright sides in ordinary use.* I there pointed out that the ordinary rectangular notches, although for many purposes suitable and convenient, are but ill-adapted for the measurement of very variable quantities of water, such as commonly occur to the engineer to be gauged in rivers and streams; because if the rectangular notch be made wide enough to allow the water through in flood times, it must be so wide that for long periods, in moderately dry weather, the water flows so shallow over its crest that its indications cannot be relied on. I showed that this objection would be removed by the employment of triangular notches, because in them, when the quantity flowing is small, the flow is confined to a narrow and shallow space, admitting of accurate measurement; and as the quantity flowing increases, the width and depth of the space occupied in the notch increase both in the same ratio, and the space remains of the same form as before, though increased in magnitude. I proposed that in cases in which it might not be convenient to form a deep pool of quiet water at the up-stream side of the weir-board, the bottom of the channel of approach, when the triangular notch is used, may be formed as a level floor, starting exactly from the vertex of the notch, and extending both up-stream and laterally, so far as that the water entering on it at all its margins may be practically considered as still water, of which the height of the surface above the vertex of the notch may be measured in order to determine the quantity flowing.

* See *C. E. & A. Journal,* vol. xxi. p. 369; also, *Journ. Fr. Inst.,* vol. xxxvii. 3d ser. p. 81.

I indicated theoretic considerations which led to the anticipation that in the triangular notch, both with and without the floor, the quantity flowing would be proportional or very nearly so to the $\frac{5}{2}$ power of the height of the still-water surface above the vertex of the notch. As the result of moderately accurate experiments which I had at that time been able to make on the flow in a right-angled notch without floor, I gave the formula $Q = 0{\cdot}317\ H^{\frac{5}{2}}$, where Q is the quantity of water in cubic feet per minute, and H the head of water, as measured vertically, in inches, from the still-water level of the pool down to the vertex of the notch. This formula I submitted at that time temporarily, as being accurate enough for use for many ordinary practical purposes, for the measurement of water by notches similar to the one experimented on, and for quantities limited to nearly the same range as those in the experiments (from about 2 to 10 cubic feet per minute), but as being subject to amendment by future experiments, which might be of greater accuracy, and might extend over a wider range of quantities of water. Having been requested by the general committee of the association to continue my experiments on this subject, with a grant placed at my disposal for the purpose, I have, in the course of last summer and present summer, devoted much time to the carrying out of more extended and more accurate experiments. The results which I have obtained are highly satisfactory. I am confident of their being accurate. I find them to be in close accordance with the law which had been indicated by theoretical considerations; and I am satisfied that the new system of gauging, now by these experiments made completely ready for general application, will prove to be of great practical utility, and will afford for a large class of cases important advantages over the ordinary methods,—for such cases especially as the very varying flows of rivers and streams.

The experiments were made in the open air, in a field adjacent to a corn mill, in Carr's Glen, near Belfast. The water supply was obtained from the course leading to the water-wheel of the mill, and means were arranged to allow of a regulated supply, variable at pleasure, being drawn from that course to flow into a pond, in one side of which the weir-board with the experimental notch was inserted. The inflowing stream was so screened from the part of the pond next the gauge notch as to prevent any sensible agitation being propagated from it to the notch, or to the place where the water level was measured. For measuring the water level a vertical slide wand was used, with the bottom end cut to the form of a hook, the point of which was a small level surface of about $\frac{1}{8}$ inch square. This point of the hook, by being brought up to the surface of the water from below, gave a very accurate means for determining the water level, or its rise or fall, which could be read off by an index-mark near the top of the wand, sliding in contact with the edge of a scale of inches on the fixed framing which carries the wand.

By other experiments a sharp pointed hook, like a fishing-hook, has sometimes, especially of late, been used for the same purpose, and such a hook affords very accurate indications. The result of my experience

however leads me to incline to prefer something larger than the sharp-pointed hook, and capable of producing an effect on the water surface more easily seen than that of a sharp-pointed hook; and on the whole I would recommend a level line, like a knife-edge, which might be from one-eighth to half an inch long, in preference either to a blunt point with level top, or a sharp point. The blunt point which I used was so small, however, as to suit very perfectly. If the point be too large, it holds the water up too much on its top, as the water in the pond descends, and makes too deep a pit in the surface as the water ascends and begins to flow over it. The knife-edge would be free from this kind of action, and would, I conceive, serve every purpose perfectly, except when the water has a velocity of flow past the hook, and in that case, perhaps, the sharp point, like that of a fishing-hook, might be best.

To afford the means for keeping the water surface during an experiment exactly at a constant level, as indicated by the point of the wooden hook, a small outlet waste sluice was fitted in the weir board. The quantity of water admitted to the pond was always adjusted so as to be slightly in excess of that required to maintain the water level in the pond slightly above the height at which the hook was fixed for that experiment. Then a person lying down, so as to get a close view of the contact of the water surface with the point of the hook, worked this little waste or regulating sluice, so as to maintain the water level constantly coincident with the point of the hook.

The water issuing from the experimental notch was caught in a long trough, which conveyed it forward with a slight declivity, so as to be about 7 feet or 8 feet above the ground further down the hill-side, where two large measuring barrels were placed side by side, at about 6 feet distance apart from centre to centre. Across and underneath the end of the long trough just mentioned, a tilting trough 6 feet long was placed, and it was connected at its middle with the end of the long trough by a leather flexible joint, in such a way that it would receive the whole of the water without loss, and convey it at pleasure to either of the barrels, according as it was tilted to one side or the other.

Each barrel had a valve in the bottom, covering an aperture 6 ins. square, and the valve could be opened at pleasure, and was capable of emptying the barrel very speedily. The capacity of the two barrels jointly was about 130 gallons, and their contents up to marks fixed near the top for the purpose of the experiments was accurately ascertained by gaugings repeated several times with two or four-gallon measures with narrow necks.

By tilting the small trough so as to deliver the water alternately into the one barrel and the other, and emptying each barrel by its valve while the other was filling, the process of measuring the flowing water could be accurately carried on for as long time as might be desired. With this apparatus, quantities of water up to about 38 cubic feet per minute could be measured with very satisfactory accuracy.

The experiments of which I have now to report the results were made

on two widths of notches in vertical plane surfaces. The notches were accurately formed in thin sheet iron, and were fixed so as to present next the water in the pond a plane surface, continuous with that of the weir board.

The one notch was right-angled, with its sides sloping at 45° with the horizon, so that its horizontal width was twice its depth. The other notch had its sides each sloping two horizontal to one vertical, so that its horizontal width was four times its depth.

In each case experiments were made both on the simple notch without a floor, and on the same notch with a level floor starting from its vertex, and extending for a considerable distance both up-stream and laterally. The floor extended about 2 feet on each side of the centre of the notch, and about $2\frac{1}{2}$ feet in the direction up-stream, and this size was sufficient to allow the water to enter on it with only a very slow motion, so slow as to be quite unimportant. The height of the water surface above the vertex of the notch was measured by the sliding hook at a place outside the floor, where the water of the pond was deep and still.

H.	Q.	C.
7	39·69	·3061
6	26·87	·3048
5	17·07	·3053
4	9·819	·3068
3	4·780	·3067
2	1·748	·3088

The principal results of the experiments on the flow of the water in the right-angled notch without floor are briefly given in the annexed table, the quantity of water given in column 2 for each height of 2, 3, 4, 5, 6, and 7 inches, being the average obtained from numerous experiments comprised in two series, one made in 1860, and the other made in 1861, as a check on the former set, and with a view to the attainment of greater certainty on one or two points of slight doubt. The second set was quite independent of the first, the various instruments and gaugings being made entirely anew. The two sets agreed very closely, and I present an average of the two sets in the table as being probably a little more nearly true than either of them separately. The third column contains the values of the co-efficient C, calculated for the formula $Q = C\,H^{\frac{5}{2}}$, from the several heights and corresponding quantities of water given in the first and second columns; H being the height, as measured vertically in inches from the vertex of the notch up to the still-water surface of the pond; and Q being the corresponding quantity of water in cubic feet per minute, as ascertained by the experiments. It will be observed from this table that, while the quantity of water varies so greatly as from $1\frac{3}{4}$ cubic feet per minute to 39, the co-efficient C remains almost absolutely constant, and thus the theoretic anticipation that the quantity should be proportional, or very nearly so, to the $\frac{5}{2}$ power of the depth, is fully confirmed by experiment. The mean of these six values of C is ·3064; but being inclined to give rather more weight in the determination of the co-efficient as to its amount, to some of the experiments made this year than to those of

last year, I adopt ·305 as the co-efficient, so that the formula for the right-angled notch without floor will be $Q = \cdot305\, H^{\frac{5}{2}}$. My experiments on the right-angled notch with the level floor fitted as already described, comprised the flow of water for depths of 2, 3, 4, 5, and 6 ins. They indicate no variation in the valuation of C for different depths of water, but what may be attributed to the slight error of observation. The mean value which they show for C is ·308, and as this differs so little from that in the formula for the same notch without the floor, and as the difference is within the limits of the errors of observation, I would say that the experiments prove that, with the right-angled notch, the introduction of the floor produces scarcely any increase or diminution on the quantity flowing for any given depth, but do not show what the amount of any such small increase or diminution may be, and I would give the formula $Q = \cdot305\, H^{\frac{5}{2}}$ as sufficiently accurate for use in both cases. The experiments in both cases were made with care, and are, without doubt, of very satisfactory accuracy; but those for the notch without the floor are, I consider, slightly the more accurate of the two sets.

The experiments with the notch with edges sloping two horizontal to one vertical, showed an altered feature in the flow of the issuing vein as compared with the flow of the vein issuing from the right-angled notch. The edges of the vein, on issuing from the notch with slopes 2 to 1, had a great tendency to cling to the outside of the iron notch and weir board, while the portions of the vein issuing at the deeper parts of the notch would shoot out and fall clear of the weir board. Thus, the vein of water assumed the appearance of a transparent bell, like as of glass, or rather of the half of a bell closed on one side by the weir board, and inclosing air. Some of this air was usually carried away in bubbles by the stream at bottom, and the remainder continued shut up by the bell of water, and existing under slightly less than atmospheric pressure.

The diminution of pressure of the inclosed air was manifested by the sides of the bell being drawn in towards one another, and sometimes even drawn together, so as to collapse with one another at their edges which clung to the outside of the weir board.

On the full atmospheric pressure being admitted, by the insertion of a knife into the bell of falling water, the collapsed sides would immediately spring out again. The vein of water did not always form itself into the bell, and when the bell was formed the tendency to the withdrawal of air in bubbles was not constant, but was subject to various casual influences. Now it evidently could not be supposed that the formation of the bell, and the diminution of the pressure of the confined air, could occur as described, without producing some irregular influence on the quantity flowing through the notch for any particular depth of flow, and this circumstance must detract more or less from the value of the wider notches as means for gauging water in comparison with the right-angled notch with angles at 45° with the horizon. I therefore made numerous experiments to determine what might be the amount of the ordinary, or of the greatest, effect due to the dimi-

nution of pressure of the air within the bell. I usually failed to meet with any perceptible alteration in the quantity flowing due to this cause; but sometimes the quantity seemed to be increased by some fraction, such as 1, or perhaps 2 per cent. On the whole, then, I do not think that this circumstance need prevent the use, for many practical purposes, of notches of any desired width for a given depth.

My experiments give as the formula for the notch, with slopes of 2 horizontal to 1 vertical, and without the floor—

$$Q = 0{\cdot}636\ H^{\frac{5}{2}},$$

and for the same notch, with the horizontal floor at the level of its vertex—

$$Q = 0{\cdot}628\ H^{\frac{5}{2}}.$$

In all the experiments from which these formulæ are derived, the bell of falling water was kept open by the insertion of a knife or strip of iron, so as to admit the atmospheric pressure to the interior. The quantity flowing at various depths was not far from being proportional to the $\frac{5}{2}$ power of the depth, but it appeared that the co-efficient in the formula increased slightly for very small depths, such as one or two inches. For instance, in the notch with slopes 2 to 1 without the floor, the co-efficient for the depth of 2 inches came out experimentally 0·649, instead of 0·636, which appeared to be very correctly its amount for 4 inches depth. It is possible that the deviation from proportionality to the $\frac{5}{2}$ power of the depth, which in this notch has appeared to be greater than in the right-angled notch, may be partly due to small errors in the experiments on this notch, and partly to the clinging of the falling vein of water to the outside of the notch, which would evidently produce a much greater proportionate effect on the very small flows than on great flows. The special purpose for which the wide notches have been proposed is to serve for the measurement of wide rivers or streams, in cases in which it would be inconvenient or impracticable to dam them up deep enough to effect their flow through a right-angled notch. In such cases I would now further propose that, instead of a single wide notch, two, three, or more right-angled notches might be formed side by side in the same weir board, with their vertices at the same level. In cases in which this method may be selected, the persons using it, or making comparisons of gaugings obtained by it, will have the satisfaction of being concerned with only a single standard form of gauge notch throughout the investigation in which they may be engaged.

By comparison of the formulæ given above for the flows through the two notches experimented on, of which one is twice as wide for a given depth as the other, it will be seen that in the formula for the wider notch the co-efficient ·636 is rather more than double the co-efficient ·305 in the other. This indicates that as the width of a notch considered as variable increases from that of a right-angled notch upwards, the quantity of water flowing increases somewhat more rapidly than the width of a notch for a given depth. Now, it is to be observed that the contraction of the stream issuing from an orifice open above

in a vertical plate is of two distinct kinds at different parts round the surface of the vein. One of these kinds is the contraction at the places where the water shoots off from the edges of the plate. The curved surface of the fluid leaving the plate is necessarily tangential with the surface of the plate along which the water has been flowing, as an infinite force would be required to divert any moving particle suddenly out of its previous course.* The other kind of contraction in orifices open above consists in the sinking of the upper surface, which begins gradually within the pond or reservoir, and continues after the water has passed the orifice. These two contractions come into play in very different degrees, according as the notch (whether triangular, rectangular, or with curved edges) is made deep and narrow, or wide and shallow. From considerations of the kind here briefly touched upon, I would not be disposed to expect theoretically that the co-efficient C for the formula for V-shaped notches should be at all truly proportional to the horizontal width of the orifice for a given depth; and the experimental results last referred to are in accordance with this supposition. I would, however, think that from the experimental determination now arrived at, of the co-efficient for a notch so wide as four times its depth, we might very safely, or without danger of falling into an important error, pass on to notches wider in any degree, by simply increasing the co-efficient in the same ratio as the width of the notch for a given depth is increased.

* This condition appears not to have been generally noticed by experimenters and writers on hydrodynamics. Even MM. Poncelet and Lesbros, in their delineations of the forms of veins of water issuing from orifices in these plates, after elaborate measurements of those forms, represent the surface of the fluid as making a sharp angle with the plate in leaving its edge.

MECHANICS, PHYSICS, AND CHEMISTRY.

Extracts from a Paper on the most advantageous form of Magnets. By Dr. Lamont.*

From the Lond. Edin. and Dub. Phil. Mag., November, 1861.

From the determinations it results—

1. That *narrower* magnets are more advantageous than *broader*.
2. That *thinner* magnets are more advantageous than *thicker*.
3. That consequently the most advantageous form is that in which breadth and thickness disappear, and the magnet is transformed into a mathematical line, *i. e.* into a so-called *linear magnet*.

The most advantageous form of a magnet, so far as the proportion of the magnetism to the weight is considered, is therefore an *imaginary* one; practically, however, there are two forms which appear advantageous, namely, the *flat, contracting to a point from the middle*, and the *flat prismatic:* and indeed in the former form the proportion of the magnetism to the weight is more advantageous by one-eighth part than in the latter; so that it must always hold as a rule that the thickness and breadth must be as far diminished as the other necessary conditions permit.

We should still have to investigate in what proportion in the above-

* Translated from Puggendorff's *Annalen*, vol. cxiii. pp. 239-249. Communicated by the Astronomer Royal.

mentioned forms the magnetism stands to the moment of inertia; but I consider it superfluous to annex here the tabular exhibitions relative to this, since without such it is easy to see that the form which we have pronounced as disadvantageous in reference to the weight, must also be disadvantageous as regards the moment of inertia. But as respects the flat form contracting to a point from the middle, and the flat prismatic form, which have been noted above as the only appropriate forms, the weights are, with equal length, and equal breadth in the middle, as 1 to 2, and the moments of inertia as 1 to 3·75, so that the form contracting to a point must be recognised as by far the best.

In regard to the investigation, it ought yet to be mentioned that it must prove always too much dependent on circumstantial details, and too little satisfactory, as long as we are not in a position to lay down the laws of the distribution of the magnetism and of the dependence of the magnetic moment upon the dimensions. In this latter point of view the labors hitherto employed have had only very trifling success. From numerous observations which I have made with the prismatic bars, it results that with equal thickness the magnetic moments are in the proportion of the square roots of the thickness; nevertheless, this law only obtains for greater transverse sections, and is perfectly unavailable for smaller dimensions. I have now made substitutions in the formula—

$$\sqrt{\frac{a\,x + b}{x + c}}\,x,$$

where x is the variable dimension, and a, b, c constants; and I find that it very accurately corresponds with observation in small as in great dimensions. Even when laminæ are laid together, this formula represents very well the result, as will be proved by the following table, in which the second series of experiments is calculated by the formula

$$\sqrt{\frac{12{\cdot}80 + 2{\cdot}46\,n}{n + 0{\cdot}218}}\,n.$$

Number of laminæ $= n$.	Magnetic Moment.		Difference.
	Observed.	Calculated.	
1	3·53	3·54	+ 0·01
2	4·11	4·00	— 0·11
3	4·36	4·34	— 0·02
4	4·65	4·63	— 0·02
5	4·94	4·90	— 0·04
6	5·15	5·16	+ 0·01
7	5·39	5·40	+ 0·01
8	5·61	5·62	+ 0·01
9	5·83	5·84	+ 0·01
10	6·05	6·05	0·00
11	6·27	6·25	— 0·02
12	6·44	6·45	+ 0·01

A practical inference results from the investigation, which I believe deserves to be carefully considered on the part of those who concern themselves with the manufacture of magnetic instruments. A freely movable magnet is to be employed with advantage only so far as the magnetic moment is as large as possible in proportion to the weight. But the more the transverse size is augmented, the greater is the departure from the fulfilment of this condition, and consequently the use of massive magnetic bars must be pronounced inadmissible. There is only one means of obtaining great magnetic strength with trifling weight; namely, by firmly connecting several thin and flat magnets near or upon one another in one system without their touching each other. Many years ago I began in magnetic variation instruments, later also in magnetic theodolites, to unite several magnets; and at present I use universally systems of three laminæ, which are laid upon each other and held separated in the middle by small pieces of brass of about the thickness of three-quarters of a line. Also in ships compasses several needles near each other are at present continually used with the best result. Hollow cylindrical magnets, to which some artists have given a great preference in regard to strength and lightness, remain, as can be proved even from theoretical considerations, very far behind in comparison with a single flat needle; and with this agree also the experiments which I have made.

Upon the Merits of the "Beam" Steam Engine as compared with the "Direct-Action" arrangements, as a Motive Power for Driving Machinery used in various Manufacturing Purposes. By W. B. Johnson.

From the Journal of the Society of Arts, No. 463.

The importance of ascertaining, as far as our present progress in mechanical engineering will allow, the best arrangement of stationary engine upon the reciprocating principle, will be apparent to all that have given the subject consideration. But two views are of great weight at the present time: one is the increasing demand that is being made upon motive power for driving machinery made to take the place of manual labor. The unsettled condition and increasing value of labor in this country make it almost imperative that manufactures in every department should be produced with as little dependence as possible upon labor. This is a movement that will eventually call forth a large amount of motive power, and a motive power differing considerably in its arrangement from that now generally adopted. The other view of the subject is of equal importance. If motive power is to be supplied at any thing like a moderate cost, as compared with other classes of machinery, it must assume something of a fixed form, and to such a degree as will induce the maker to apply machinery in its manufacture to a much greater extent than has hitherto been done. This would not only lessen the cost considerably, but at the same time improve the quality of the work. It is now generally admitted that machinery produced by the application of tools is in all respects much

superior to that produced by hand labor. It may safely be asserted that in no class of machinery is less advantage taken of the assistance of tools than in the production of stationary steam engines. Other reasons might be mentioned for giving the subject of this paper careful consideration. The general consent of engineers to the superiority of steam as a motive power over all other agents, and the universal adoption of the reciprocating piston as the best mode of receiving power from the same, are also ample reasons why an attempt should be made to ascertain the best arrangement for applying such motive power to manufacturing purposes.

Locomotive and marine engineers have, within a comparatively few years, made considerable progress in arriving at the most suitable arrangements of the parts composing such engines; but the stationary engine has remained almost in the same condition in which it came out of the hands of its first originators. Locomotive and marine engineers have abandoned the notion that a "beam" is a necessary part of an engine, but that in some mysterious manner an advantage is obtained by conveying the motive power through a beam, appears still to be the opinion of most engineers engaged in the manufacture of stationary engines.

The stationary beam engine, as ordinarily constructed, is one of the most imperfect pieces of mechanism produced in this country; its parts, taken in detail, are frequently specimens of most excellent workmanship, and exhibit considerable skill in the design; but, when considered as a whole, the machine is dislocated, its parts are numerous, far removed from each other, and in many places it depends upon extraneous support for giving it unity and strength. The foundation work and engine-house walls form the greater part of the framework of the engine, and the engine is thereby subjected to casualties which are quite at variance with one's conception of a perfect machine. Its forces are in various directions, the first mover, the piston, moving apparently without reference to its ultimate purpose, the rotation of the crank-shaft; it starts off, at some distance, at right angles with the shaft. As if afraid at once to face its work, it seems to court a circuitous route in preference to a direct one.

The object of this paper is to bring into comparison with the ordinary beam engine the direct-action engine, and to show the superiority of the latter over the former, and also to compare the various arrangements of direct-action engines with each other; and, before proceeding further, it may be proper to state, that the term "direct-action" engine, used in this paper, refers to that particular construction in which the power is conveyed from the piston-rod to the crank by the intervention of a connecting-rod only. The remarks to be made have special reference to condensing engines; preference has been given for some time to direct-action over the beam, for non-condensing engines, the less number of parts in a non-condensing engine making the application of the direct-action principle a simple undertaking.

The principal objections that have been made to the beam engine are:—

1st. The large amount of foundation work required.

2d. The side walls of the engine-house are required to be built of a strength considerably beyond what is required for a direct-action engine.

3d. The height required is in most cases objectionable, interfering with the lights in the rooms next to the engine-house.

4th. The number of parts through which the power is conveyed, and consequent liability to derangement.

5th. The serious results of any breakage, the parts in falling, in almost every instance of break-down, doing considerable if not all the mischief.

6th. The difficulty of observation of and access to the condensing apparatus of the engine.

7th. The entire dependence of the engine upon the foundation and engine-house walls for unity and support, any settlement in the same causing serious difficulty in re-adjusting the parts of the engine affected thereby.

These objections are named to enable a comparison to be made with the direct-action arrangements, and to ascertain how far such objections are removed by this principle of construction. Direct-action engines are of two kinds, vertical and horizontal. In the vertical, the reciprocating movement of the piston is in a vertical line with the crank-shaft, placed either above or below the cylinder. In the horizontal, the movement of the piston is in a horizontal direction; the position of the crank-shaft being constant, does not admit of the distinction just named in the vertical.

The vertical arrangement of direct-action engine requires:—

1st. Considerably less foundation work than the beam engine.

2d. The walls of the engine-house may be built independent of the engine, although in some constructions of this engine the walls are fully as much depended upon as in the beam engine; this is decidedly objectionable.

3d. The height required is equal to that of the beam engine, and it possesses no advantage over the beam engine in this respect, except that the length of the engine-house is less by about one-half.

4th. The number of parts through which the power is conveyed are equal in proportion as 2 is to 5.

5th. The results arising from break-downs are less severe than in the beam engine, although from its construction it is not free from objection on this ground.

6th. The ease of access to the condensing apparatus will greatly depend upon the arrangement adopted in this part of the engine, but the principle admits of a better one than could be applied to the beam engine.

7th. It is independent of the foundation work and engine walls for unity, "except in instances of imperfect construction;" its forces are self-contained, and it does not, therefore, suffer from settlement or changes in the building in which it is placed, to the like extent as the beam engine.

The vertical direct-action engine has the advantage over the beam engine in the 1st, 2d, 4th, and 7th points named, and also a slight advantage in the 3d and 5th points; in reference to the 6th point, "the condensing apparatus," its advantage over the beam engine will entirely depend upon the arrangement adopted for working the air-pump and the relation of its parts.

When the crank-shaft is above the cylinder, these parts may be conveniently arranged so as to be easy of access and observation, and at the same time be within a suitable distance from the cylinder; but when the crank-shaft is below the cylinder, the condenser is far removed from the cylinder, which is an objection to this description of vertical direct-action engine. From this it appears that the best arrangement of vertical direct-action engine is the one having the crank-shaft above the cylinder. A very excellent engine can be made by having the cylinder, condenser, air-pump, and frame-work well secured to one strong foundation plate; such an engine would be compact, yet easy of access to all its parts, and would possess that unity which is absolutely necessary for perfection in every class of machinery. Were it not that the particular position of the crank-shaft is inapplicable in most cases where power is required, this construction of engine would merit the careful consideration of engineers to bring it up to a standard point of perfection.

The horizontal arrangement of direct-action engine, when compared with the beam engines, requires:—

1st. Less foundation work, although this varies according to the different modes of working the air-pump.

2d. The engine is wholly independent of the engine-house walls, consequently they may be reduced to a minimum in strength.

3d. The height required is much less, being from one-third to one-half of that necessary for a beam engine.

4th. The number of parts through which the power is conveyed is reduced in proportion as 2 is to 5.

5th. The results of break-downs are much less destructive, the whole of the working parts being within a limited distance from the floor, and therefore cannot cause any injury in falling.

6th. The condensing apparatus, and all other parts of the engine, are easy of observation and access, except in some arrangements about to be referred to.

7th. It is independent of the foundation work and engine-house walls for unity; its forces are self-contained, and it does not therefore suffer from settlement or changes in the building in which it is placed, to the same extent as the beam engine.

The horizontal direct-action engine has the decided advantage of the beam engine in the 1st, 2d, 3d, 4th, 5th, 6th, and 7th points of comparison, and also has some advantages over the direct-action on the vertical arrangement. For general purposes, the crank-shaft is conveniently situated; the lines of movement and position of the working parts are also conveniently placed for observation and access; these considerations point to this arrangement of engine as the most

suitable for general adoption, and it merits from engineers and those requiring motive power, that consideration and attention necessary to place it in its proper position as the best arrangement of stationary steam engine.

Various modes have been adopted for working the air-pump in horizontal direct action engines—the relative positions of the condensing apparatus is a question of the utmost importance in endeavoring to make this engine efficient in working, compact and united in its parts, and at the same time easy of access for examination. One arrangement for acccomplishing this consists in working the air-pump from the crank-pin, by a supplementary crank and shaft, and in some cases levers actuated by the crank-pin are employed for this purpose; but either of these, or any other mode of working the air-pump from the crank-pin, are objectionable; the parts of the engine are necessarily separated from each other—there is a want of unity and compactness; the strains are in various directions; the foundation work is considerably extended; and the air-pump and condenser are so far below the engine-house floor as to be inconvenient for examination.

Another mode of working the air-pump is by levers attached by links to the piston-rod, cross-bar, or mounting, in some arrangements of which the fulcrum of the levers is fixed above the horizontal centre line of the engine, and in some below. This may in some respects be superior to the mode first named, but still objection can reasonably be made to the number of parts required, and consequent liability to derangement. The strains are in a variety of directions; it is not united and compact; it requires extra foundation, and is frequently difficult of access for examination.

Perhaps the most correct notion of working the air-pump is that of attaching the air-pump rod direct to the piston-rod, without the intervention of levers, links, or any movable joints. One mode of effecting this is by placing the air-pump a slight distance from the end of the cylinder furthest from the crank-shaft, and attaching the air-pump rod to the piston-rod, which works through the back cylinder cover. This arrangement adds considerably to the length of the engine, and to avoid this, the connecting-rod is frequently made much shorter than is desirable for easy working. Another mode of carrying this arrangement out is effected by placing the air-pump near to the end of the cylinder next to the crank, the piston-rod being continued through the air-pump on to the piston-rod mounting; the air-pump is between the piston-rod mounting and the cylinder end. The same objection applies to this mode, in regard to length, as to the former one, and attempts are made to overcome the difficulty in the same objectionable manner, "shortening the connecting-rod," and by cramping up the parts, so as to make them difficult of access. Another and third mode of working the air-pump direct from the piston-rod, consists in placing the air-pump between the piston-rod mounting and crank, the space between the air-pump and cylinder being sufficient to allow for the working of the piston-rod mounting and guide blocks. The extra length of the engine is not so much as in the former arrangements, and what

extra length is required, is added to the length of the connecting-rod.

The three constructions of engines just mentioned have in common considerable advantages over any other of the direct-action arrangements named in this paper. The foundation is a level bed, less in extent, without any breaks or depressions, and can, therefore, be more firmly bound together; the number of working parts is brought down to a minimum, not exceeding in joints and working surfaces beyond what is required for a non-condensing engine; the liability to derangement is consequently reduced in equal proportion. Every part of the engine is within the limits of easy examination, no part being under the engine-house floor, nor so far above it as to require any stage-work, or second height of flooring. The strains are self-contained, and are all in one direction, and admit of a maximum unity and strength to be obtained with a minimum amount of material.

Other advantages peculiar to this arrangement—"working the air-pump direct"—might be mentioned, but sufficient has been said to show that it possesses claims which entitle it to the attention of all interested in the production and use of stationary steam engines.

Engines have been made upon the various plans referred to, and they have shown in their comparative efficient working most clearly the truth of that almost universally admitted opinion in mechanical engineering, "that the success of a machine is in proportion to its simplicity," of course, supposing correct principles to be adopted in the construction. Engines have been made upon the arrangement last mentioned, in which convenience of access is carried to an extent far beyond what would have been considered possible a few years ago; air-pump foot and delivering valves can be taken out and replaced, air-pump bucket packed, and cylinder-piston examined, within one hour, and without the employment of extra labor beyond what is usual for such purposes. Facilities for examination are next in importance to the good working of an engine, and cannot be too carefully provided for; and, in reference to special and economical working, this arrangement compares most favorably with all other constructions of engines hitherto adopted.

Great freedom has been taken with the beam engine in pointing out some of its defects, or which may fairly be considered objections to it, and it will now only be doing justice to subject the direct-action principle to the same ordeal.

To the vertical direct-action arrangement, no objections can be named beyond those already mentioned, but to the horizontal arrangement an objection was raised at its first introduction, and is still maintained by engineers of undoubted celebrity. The horizontal position of the cylinder is objected to on account of the piston in its movement wearing the lower more than the upper side of the cylinder; now, this is a question that can be best decided by a careful reference to the numerous examples of this kind of engine now at work; facts bearing upon this question can be obtained in almost any quantity, and it is desirable the task should be undertaken to ascertain how far

this objection can be sustained. The horizontal principle in all probability will be extensively adopted for engines of a maximum size, and it would be well to ascertain, before proceeding too far in this direction, the true value of this objection. It has been found that, in all instances in which proper care has been taken, this objection is groundless, and cylinders upon the horizontal arrangement are wearing as equally as those placed vertically. It may be proper to remark that in horizontal engines too much care cannot be bestowed in endeavoring to make the piston and mounting and guide-blocks as perfect as possible. The surfaces should be large, to prevent rapid wearing down, and the construction should be such as will admit of the piston-rod mounting being easily adjusted to its correct centre with the cylinder. With such arrangements, and the parts correctly made and put together, the evils implied in the objection just named are found in practice fully provided against.

No reference has been made to the various kinds of valve arrangements applied to the cylinders of engines, whether beam or direct-acting. The direct-action does not in this respect compare unfavorably with the beam engine; the horizontal arrangement, perhaps, has the advantage of any other in admitting valves of any construction to be applied in a simple and an efficient manner.

Reference has not been made to the other detail parts, the object of this paper being principally to deal with the broad question—Beam *versus* Direct-action; and, on this point, the distinctive features in all the arrangements considered, and those by which the type of the engine is chiefly affected, are, the position and mode of working the air-pump, and, therefore, almost exclusive attention has been given to them.

Before concluding, it may be proper to draw attention to the manner in which most horizontal engines have hitherto been made. The ignorance displayed in many designs, and the imperfect character of the material and workmanship employed, have done much to bring the principle into disrepute; engines of bad construction have been put to a duty far above their capabilities. As a matter of course, they have given no satisfaction, but much trouble, and the principle at last bears the whole of the blame, when, in fact, it has nothing whatever to do with it. The horizontal engine is simple, but that is no reason why it should not be good in design, and of proper materials and workmanship; let the horizontal engine have skilful and careful attention in the design, be well executed, and put to its proper amount of duty, and it will not be long before it attains that position as the best of engines to which its beautiful simplicity so justly entitles it.

Unsinkable and Incombustible Ships.

From the Journal of the Society of Arts, No. 465.

The *Briton*, new screw steamer, destined for the Cape mail service, and now lying in the river off Deptford, is the first specimen of a novel system of ship-building, invented by Mr. Charles Lungley, who

claims for his invention—which is patented—two great advantages, viz: safety from destruction by water, and, to a great extent, security against fire. Each deck of the vessel is distinct from the others, having no communication with them, but having its separate hatchway or entrance from the upper deck; the object of this arrangement being, that whatever injury may be incurred by either one or even by two of these decks or stories, the other or others will float. Thus, for instance, should the lower or keel deck be knocked away, the two upper decks will float the ship; or should, either from a collision, the starting of a plate under the water line, or from a shot or a broadside penetrating the sheathing, one of the intermediate decks let in the water, even to the extent of filling the compartment from stem to stern, the buoyant power would still remain, and the vessel would not only float, but be perfectly manageable, the water merely rising up the trunk hatchway of that particular deck to the level of the water line outside, allowing full opportunity for a diver to descend, find out the place and extent of the injury, and repair it if capable of repair, after which the water might be pumped out and the ship freed.

The same subdivision of decks which affords the security against entire submersion, ensures protection against total destruction by fire. In the event of a fire being discovered on either deck, the hatchway of that deck would be fastened down, and the supply of air being thus cut off, the fire would die out of itself; or if the fire had got too much hold upon the ship to allow of this, then the entire deck in which the conflagration was raging might be filled with water without risk of other inconvenience than that of having to pump it out again.

Another advantage of this mode of ship-building is the perfect ventilation it is said to insure to all parts of the vessel. At present the general practice is to have one main hatchway, which communicates from the upper deck to all the several floors on the ship, and which forms the ventilating shaft from each. It is easy to imagine in cases when fever breaks out on board, how much the danger is likely to be increased by such an arrangement, or when large numbers of troops or emigrants are berthed below, how much the risk of disease is increased by such imperfect ventilation. By Mr. Lungley's plan, each deck has its own ventilating shaft or shafts—for there may be one, two, or more—in the hatchways, which are its means of communication from above. These separate shafts likewise afford facilities for loading and unloading, which will be appreciated in merchant ships.

The practice of dividing iron ships into water-tight compartments, with the view of preventing their sinking, has been followed for many years, but the division walls have in all cases been transverse; that is, each deck has been divided by water-tight iron bulkheads into three, four, or more separate rooms or apartments—the impression being that should one or two become by leakage filled with water, there would be buoyancy enough in the others to keep the ship afloat. Experience has unfortunately, however—and the case of the *Connaught* is a prominent instance among many—proved the unsoundness of this theory. The fact is, that when any one of the compartments becomes

filled with water, or ships water in any considerable quantity, the vessel is unduly depressed in that particular part, and no longer sails with an even keel. To remedy this, it would be necessary to let in a corresponding weight of water in the opposite compartments, which, in all probability, even if practicable, would bring the ship down so low in the water that, with anything like a sea on, she would sink, or the wash from side to side would lay her over on her broadside; whereas, if she were left with her keel out of the level, she would, as the water gained upon her, go down head or stern foremost, as the case might be. By making the decks themselves the water-tight divisions, the weight of water in case of leakage is equalized over the whole surface of the ship, and the even keel, which is the main element of safety, is preserved, while all danger is localized, and thus proportionately reduced.

One thing which strikes the attention of the visitor on board the *Briton*, is the perfect isolation of the engine-room. Not only is it protected by the water-tight deck division, but longitudinal bulkheads or iron walls, running fore and aft some feet within the outer shell or sides of the vessel, protect it from the chance of injury from without. Thus a fracture in the outside plates occasioned by collision, stranding, or shot, although it might admit the water into the ship, would not affect the engines or the fires. The importance of this arrangement of longitudinal inside walls for the protection of the machinery, especially in ships of war, where it may be carried throughout the vessel, for adding to the stability of the entire structure, seems very great. The vessel is now complete, ready for sea, and in the meanwhile her builder, Mr. Lungley, invites those who take an interest in such subjects to inspect her, and, to a large extent, the invitation has been accepted and acted upon by merchant ship-owners, and officers connected with the navy and the merchant service.

Piassava Brooms.

From the Lond. Mechanics' Mag., September, 1861.

For some years past, says the *Technologist*, the streets of London, Manchester, Leeds, Birmingham, and other large towns, have been, in some places at least, kept peculiarly neat and clean by brooms and brushes made of a new material. This material is the coarse, chocolate-colored fibre of the piassaba or piassava, a species of palm which grows in Brazil and Venezuela, near the Casiquiari and neighboring tributaries of the Amazon and the Orinoco. Another kind of piassava, which grows also near the same rivers, yields a finer fibre, which is dyed, mixed with bristles, and used in the manufacture of cheap clothes-brushes, and for hose-brushes. This latter variety is exported from Para, but it forms only a small proportion (not more than four or five per cent.) of the piassava used in this country. The variety used for brooms is shipped chiefly from Bahia, where it is now regarded as a staple export, and is regularly quoted in the Bahia prices current.

Piassava fibre has been used from a very early period for the manu-

facture of cordage in the regions bordering upon the Amazon. The Indians collect it in the forests, and large quantities are used in their villages to form cables for their canoes. These cables are easily made, very durable, and admirably adapted for cordage. Before Brazil became an independent empire, the Portuguese had a factory for the manufacture of piassava into cordage for the use of their arsenal at Para, and as a government monopoly. This cordage is very light, floats upon water, and is more durable in the navigation of rivers than ropes of hemp. It is extensively used in the Brazilian navy.

In England, piassava fibre has been used for about twenty-five years past. At first, its value was unknown, and some of the early arrivals were thrown into the Thames. When a Customs duty was imposed upon it, importers would not take it out of bond. The first bundle of it that arrived in Liverpool had been made up in Para as a "fender," to let down over the bulwarks, to prevent injury by collision or grazing against the sides of other vessels, the dock-gates, quays, &c. This bundle was afterwards thrown upon the quay; a working brushmaker picked it up and made a few brushes from it. These were found to answer so well, that a firm afterwards imported a small quantity, and their speculation was so successful that the sugar-vessels loading at Bahia for Liverpool, began to bring small quantities of it regularly as "dunnage." Thus the trade began about seventeen years ago. Small bundles of about ten pounds each were used to pack between the sugar-boxes and by the sides of the vessels. These at first were sold with difficulty at about £5 per ton. The brushmakers finding the article to be very useful and cheap, demanded a larger supply. At first each vessel brought from five to ten tons, and as the price increased and freights became lower, larger quantities were shipped, some vessels bringing as much as 100 tons. One vessel just arrived in London has brought over 200 tons, and many vessels bring from 50 to 100 tons at a time. It is now carried as freight, and not, as formerly, for dunnage.

The coarser piassava fibre is now brought to this country in bundles of ten to fourteen pounds each. In 1856, 270,071 bundles were shipped at Bahia, and in 1858, 278,417 bundles. It sells at £17 to £18 per ton. The quantity of finer fibre brought from Para reaches some years 150 tons. The selling price is at the rate of £37 to £38 per ton.

The nuts of the piassava tree are also imported from Bahia into England under the name of "coquillas" or coquilhos. Being excessively hard, beautifully mottled with dark and light brown, and capable of taking a very high polish, they are extensively used for turnery work, especially for the handles of bell-pulls, the knobs of walking-sticks and umbrellas, egg-cups, humming-tops, small boxes, and similar articles.

Extraordinary Electric Spark.

The Abbé Moigno, the editor of the Parisian journal *Cosmos*, witnessed an experiment in which the discharge of an induction apparatus constructed by M. Ruhmkorff, capable of giving a spark 18 inches long, pierced a mass of glass two inches thick.—*Cosmos.*

For the Journal of the Franklin Institute.

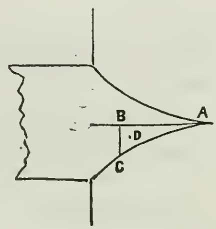
On some Beams of Uniform Strength.

The following problems, although more curious than practical, are interesting illustrations of the *theory of the resistance of beams.* With the exception of the first case, they are new to the writer.

The first case may be found in Robinson's *Mechanical Philosophy*, and "Navier's *Résumé des Leçons*," p. 249, in which the solutions differ from each other, and from the following.

I. General Problem.—*Required the form of a beam of uniform strength; the beam being fixed at one end, and the weight of the beam being the only load.*

1st Case.—Let the breadth be uniform.



Let $b =$ the breadth.
$w =$ the weight of a unit of volume.
$y =$ B C $=$ the variable depth.
$x =$ A B.
D be the centre of gravity.

Then, $\int_0^x y\,dx =$ the area A B C.

$$\frac{\int_0^x x\,y\,dx}{\int_0^x y\,dx} = \text{the abscissa of the centre of gravity D from A.}$$

Now the moment of the load on the section B C is the weight of the beam, A B C, multiplied by the distance of the centre of gravity, D, from the section, which must equal the moment of resistance of the section, which is $\frac{1}{6}\,\mathrm{R}\,b\,y^2$ for rectangular sections.

$$\therefore \qquad \left\{ w\,b \int_0^x y\,dx \right\} \left\{ x - \frac{\int_0^x y\,x\,dx}{\int_0^x y\,dx} \right\} = \tfrac{1}{6}\,\mathrm{R}\,b\,y^2. \quad \cdot \quad \cdot \quad (1)$$

Expand and differentiate once, and we obtain

$$d\,x \int_0^x y\,dx = \frac{\mathrm{R}}{6\,w}\,d\,(y^2).$$

The second differential is

$$\frac{d^2\,(y^2)}{d\,x^2} = \frac{6\,w}{\mathrm{R}}\,y. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Let $y^2 = z$. $\quad \therefore\ y = z^{\frac{1}{2}}$. And we have,

$$\frac{d^2\,z}{d\,x^2} = \frac{\mathrm{c}\,w}{\mathrm{R}}\,y^{\frac{1}{2}}.$$

Multiply by $2\,dz$, and integrate, and we have,

$$\frac{dz^2}{dx^2} = \frac{8w}{\mathrm{R}} z^{\frac{3}{2}} + \mathrm{c}\,*. \qquad (3)$$

But $\dfrac{dz}{dx} = 0$ for y or $z = 0$. $\therefore$ $\mathrm{c} = 0$.

$$\therefore \qquad z^{-\frac{3}{4}}\,dz = \sqrt{\frac{8w}{\mathrm{R}}}\,dx,$$

of which the integral is

$$4\,z^{\frac{1}{4}} = 4\,y^{\frac{1}{2}} = \sqrt{\frac{8w}{\mathrm{R}}}\,x + \mathrm{c}.$$

But $y = 0$ for $x = 0$. $\therefore$ $\mathrm{c} = 0$.

$$\therefore \qquad y = \frac{w}{2\,\mathrm{R}} x^2, \qquad (4)$$

which is the equation of a parabola, the axis being vertical. It is evident that a similar curve may be formed above, as shown in the figure.

2D CASE.—Let the depth be constant.
Let d = the depth.
u = the variable breadth.

Then we have, for the same reason as before,

$$\left\{w\,d\int u\,dx\right\}\left\{x - \frac{\int u\,y\,dx}{\int u\,dx}\right\} = \tfrac{1}{6}\,\mathrm{R}\,u\,d^2. \qquad (5)$$

which, by two differentiations, reduces to

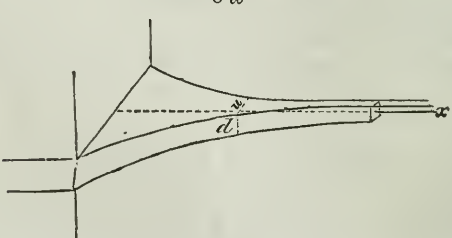
$$\frac{d^2u}{dx^2} = \frac{6w}{\mathrm{R}\,d}u.$$

The complete integral is

$$x = -\sqrt{\frac{\mathrm{R}\,d}{6w}}\log.\left[\sqrt{\frac{\mathrm{R}\,d}{6w}\mathrm{c} + u^2} - u\right] + \mathrm{c}',$$

in which c and c′ are the constants of integration. We see that the curve is logarithmic. From the nature of the problem, we know that $\dfrac{du}{dx} = 0$ for $u = 0$. $\therefore$ $\mathrm{c} = 0$.

$$\therefore \qquad x = -\sqrt{\frac{\mathrm{R}\,d}{6w}}\log.\,u + \mathrm{c}'.$$



* Can this equation be integrated in finite terms when c is not zero?

If the origin be at the point where $u = 1$, then $x = 0$ for $u = 1$. $\therefore$ $c' = 0$, and the equation becomes

$$x = -\sqrt{\frac{\text{R}\,d}{6\,w}}\log.u.$$

or,

$$u = e^{-\sqrt{\frac{6\,w}{\text{R}\,d}}x},$$

in which $x = \infty$ for $u = 0$; or the beam must be infinitely long before its breadth will vanish.

3D CASE.—Let the sections be circles, or the beam be a conoid of revolution.

We shall obtain

$$\left\{w\int \pi\,y^2\,d\,x\right\}\left\{x - \frac{\int \pi\,y^2\,x\,d\,x}{\int \pi\,y^2\,d\,x}\right\} = \tfrac{1}{4}\,\pi\,\text{R}\,y^3.$$

$\frac{1}{4}\,\pi\,\text{R}\,y^3$ is the moment of resistance of a circular section.

By differentiation we obtain,

$$y^2\,d\,x^2 = \frac{\text{R}}{4\,w}d^2(y^3).$$

Let $y^3 = z$, and we readily obtain, by observing that the constants of integration are zero,

$$y = \frac{4\,w}{5\,\text{R}}x^2,$$

which is the equation of a parabola with its axis perpendicular to the axis of the beam.

By comparing it with equation (4), we see that the parameter is $1\frac{3}{5}$ times as great; hence, a beam formed by the revolution of the parabola of the first case about the axis of x, gives a conoid of excessive strength.

4TH CASE.—Let the sections be similar; rectangular, elliptical, or any other form.

This is a more general case than the preceding, but the solution is precisely similar, and we obtain a similar result.

5TH CASE.—Suppose a weight, P, is attached to the free extremity, and the breadth is uniform—the weight of the beam still being considered.

The moment of this weight is

$$\text{P}\,x,$$

which must be added to the first member of equation (1). By differentiating twice, this term disappears, and we finally obtain equation (2), the first integral of which is equation (3), in which C is not zero. As I am unable to integrate this in finite terms, I cannot determine the class of the curve.

6th Case.—Let the load be as for the 5th case, but the depth uniform.

The $P x$ must be added to the first member of equation (5), but in the integration, $\frac{d u}{d x}$ is not zero, for $u = 0$, but is $\frac{6 P}{R d^2}$, obtained from the equation $P x = \frac{1}{6} R u d^2$. But we may make $x = 0$ for $u = 0$. Hence the curve is

$$x = -\sqrt{\frac{R d}{6 w}} \log. \left[\sqrt{\frac{6 P}{R d^3 w} + u^2} - u \right] \sqrt{\frac{R d^3 w}{6 P}}.$$

7th Case.—We would proceed in a similar manner if the load were uniformly distributed over its whole length.

8th Case.—The problem may be still further complicated by supposing that the beam is uniformly loaded, and has a load at the free extremity.

II. General Problem.—*Let the beam be fixed at one extremity, and its weight neglected.*

I will consider two cases.

1st. Suppose a weight, P, is applied at the free extremity, and the *moment of inertia* of the sections constant.

We may take any beam whose breadth changes independent of its depth, or otherwise, any beam whose sections are not circles.

Let y = the depth.
u = the breadth.
I = the moment of inertia.
$\frac{1}{2} y$ = the distance of the most remote fibre from the neutral axis.
A a constant depending upon the form of section, and the other constants of the equation.

Then, $R \frac{I}{\frac{1}{2} y}$ is the moment of resistance of the section, equal to

$$A \frac{(u y^3)}{y},$$

which equals the moment of applied force, or

$$P x = A \frac{(u y^3)}{y};$$

but, $u y^3 = C =$ constant;

$$\therefore \qquad P x = \frac{A C}{y},$$

which is the equation of a hyperbola referred to its asymptotes, and is the equation of the vertical section of the beam.

From the equation $u y^3 = \mathrm{C}$ we obtain,

$$\frac{y^3}{y} = \sqrt[3]{\frac{\mathrm{C}^2}{u^2}},$$

which, in the preceding equation, gives

$$\mathrm{P}\,x = \mathrm{A}\,\sqrt[3]{\mathrm{C}^2 u},$$

which is the equation of horizontal sections.

2d. We would proceed in the same way if the beam be uniformly loaded, and obtain

$$\tfrac{1}{2}\,\mathrm{P}\,x^2 = \mathrm{A}\frac{(u y^3)}{y} = \frac{\mathrm{A\,C}}{y}.$$

D. W.

On the Surface-Condensation of Steam. By J. P. Joule, LL.D., F.R.S.

From the Lond. Ed. and Dub. Phil. Mag., November, 1861.

In the author's experiments steam was passed into a tube, to the outside of which a stream of water was applied, by passing it along the concentric space between the steam-tube and a wider tube in which the steam-tube was placed. The steam-tube was connected at its lower end with a receiver to hold the condensed water. A mercury gauge indicated the pressure within the apparatus. The principal object of the author was to ascertain the conductivity of the tube under varied circumstances, by applying the formula suggested by Professor Thomson—

$$\mathrm{C} = \frac{w}{a}\log\frac{\mathrm{V}}{v},$$

where a is the area of the tube in square feet, w the quantity of water in pounds transmitted per hour, V and v the differences of temperature between the inside of the steam-tube and the refrigerating water at its entrance and at its exit. The following are some of the author's most important conclusions:

1. The pressure in the vacuous space is sensibly the same in all parts.
2. It is a matter of indifference in which direction the refrigerating water flows in reference to the direction of the steam and condensed water.
3. The temperature of the vacuous space is sensibly equal in all its parts.
4. The resistance to conductivity must be attributed almost entirely to the film of water in immediate contact with the inside and outside surfaces of the tube, and is little influenced by the kind of metal of which the tube is composed, or by its thickness up to the limits of that of ordinary tubes.
5. The conductivity increases up to a limit as the rapidity of the stream of water is augmented.
6. By the use of a spiral of wire to give a rotary motion to the

water in the concentric space, the conductivity is increased for the same head of water.

The author, in conclusion, gives an account of experiments with atmospheric air as the refrigerating agent; the conductivity is very small in this case, and will probably prevent air being employed for the condensation of steam except in very peculiar circumstances.

On a newly discovered Action of Light. By M. Niepce de St. Victor.

From the Lond. Edin. and Dub. Phil. Mag., November, 1861.

When the freshly broken part of an opaque porcelain plate was exposed to a strong sun for two or three hours, and then placed on chloride of silver paper, after twenty-four hours contact the silver was found to be reduced in the part corresponding to that which had been exposed to light, but there was no reduction in that part which had been preserved from light. Certain fine specimens of porcelain acquire this activity more easily.

A steel plate polished at one part, and roughened at another by the action of aquafortis, and well cleaned by alcohol, was exposed to the sun for two or three hours under the following conditions:—half the polished and unpolished plate under an opaque screen, and the other half under a white glass. The plate was then covered by a paper prepared with albuminized chloride of silver. After twenty-four hours contact, an impression was formed on the unpolished part which had been exposed to the light, but none on the polished part, nor on the unpolished part under the screen. A roughened glass plate carefully cleaned gave similar results.

These experiments show that it is not necessary for the reduction of silver salts that there be a chemical action, as when a metallic salt is insulated with an organic matter. M. Arnaudon has repeated some of these experiments with different gases, and has obtained the same results as with air.

I may here recall a previous observation, that the insulated earth exhibits traces of this action to a depth of a metre, the thickness varying, of course, with the nature of the soil and the degree of insulation. The following experiment supports this view:—In a tin tube lined with pasteboard impregnated with tartaric acid, and insulated so as strongly to reduce silver salts, I placed in the middle of the tube, but not in contact, a small bladder containing a weak solution of starch; after forty-eight hours this starch feebly reduced Barreswil's liquor, while other starch placed in the same conditions, excepting the insulation, produced no effect upon the liquor.

The following experiments were made with a view of trying whether light could magnetize a steel bar, as has frequently been stated. Avoiding all sources of error, a knitting-needle suspended by a hair was entirely unattracted by another needle insulated for a very long time in a beam of light concentrated by a strong lens, whether the light was white or had traversed a violet glass.

I then enclosed a needle in a paper impregnated with nitrate of uranium, or tartaric acid, and insulated; I also suspended a needle horizontally in tubes containing insulated pasteboard; and the results were always negative, as also was the case with experiments made with very feebly magnetized needles in the hope of demagnetizing them.

In conclusion, this persistent *activity* imparted by light to porous bodies cannot be the same as phosphorescence; for, from Becquerel's experiments, it would not continue so long: it is probable that, as Foucault believes, it is a radiation invisible to our eyes, and which does not traverse glass.—*Comptes Rendus*, July 1, 1861.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By WM. BRYSON, Civ. Eng.

(Continued from page 43.)

Abstract from Mr. Tredgold's table, continued from page 41.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
10	2100	2077	2045	2007	1964	1916	1865	1811
11	2550	2520	2490	2450	2410	2358	2305	2248
12	3040	3020	2970	2930	2900	2830	2780	2730

Table showing the calculated weight from Mr. Tredgold's formula, in hundredweights and tons,

$$\frac{9562\, d^4}{4\, d^2 + \cdot 18\, l^2} = \text{w}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
10	2100·34	2074·62	2042·45	2004·48	1961·37	1913·89	1862·77	1808·78
11	2548·47	2522·54	2489·98	2451·31	2407·12	2358·08	2304·86	2248·15
12	3039·30	3013·23	2980·35	2941·14	2896·10	2845·83	2790·91	2732·00
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
10	105·01	103·73	102·12	100·22	98·06	95·69	93·13	90·43
11	127·42	126·12	124·49	122·56	120·35	117·90	115·24	112·40
12	151·96	150·66	149·01	147·05	144·80	142·29	139·54	136·60

Abstract (continued) from Mr. Haswell's table, entitled

"Table showing the Weight or Pressure a Column of Cast Iron will Sustain with Safety."

	Length or height in Feet.							
	6	8	10	12	14	16	18	20
Inch.								
10	245,700	243,009	239,265	234.819	229,788	224,172	218,205	211,887
11	298,350	294,840	291,330	286,650	281,970	275,886	269,685	263,016
12	355,680	353,340	347,490	342,810	339,300	331,110	325,260	319,410

Table showing the calculated weight from Mr. Haswell's formula, in pounds and tons,

$$\frac{10{,}000\, d^4}{4\, d^2 + \cdot 18\, l^2} = \text{w}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
10	246.014	243,001	239.234	234,785	229,737	224,175	218,188	211,864
11	298,503	295,467	291,653	287,123	281,948	276,203	269,969	263,327
12	355,995	352,941	349,090	344,497	339,222	333,333	326,901	320,000
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
10	109·82	108·48	106·80	104·81	102·56	100·07	97·40	94·58
11	133·26	131·90	130·20	128·17	125·86	123 30	120·52	117·55
12	158·92	157·55	155 84	153·79	151·43	148·80	145·93	142·85

Table showing One-Tenth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Flat Ends.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
10	277·38	235·84	200·10	170 38	146·00	126·06	109·71	96·21
11	349·00	301·38	259 20	223·24	193·12	168·05	147·20	129·79
12	428 89	375·37	326·74	284·35	248·15	217·54	191·72	169·92

Table showing One-Fourth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Rounded Ends.

10	563·30	446·54	358·03	291·53	241·16	192·36	157·46	131 63
11	728·20	589·06	479·73	395·29	330 00	275·27	225·32	188·36
12	915·26	753·89	622·91	519·10	437·20	372·27	312·53	261·26

Table showing One-Fourth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Flat Ends.

10	693·45	589·60	500·25	425·95	365·01	315·16	274·29	240·54
11	872·52	753·47	648·01	558 11	482·81	420·14	368·01	324·47
12	1072 23	938·43	816·86	710·87	620·38	543·85	479·31	424·80

Table comparing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron, with Both Ends Rounded and with Both Ends Flat, deduced from the results of Mr. Hodgkinson's experiments on the resistance of solid uniform cylinders of cast iron to a force of compression. Low Moor Iron, No. 3.

Length or height of Pillar in inches.	Diameter in inches.	Number of diameters contained in the length or height.	Ends turned so that the force would pass through the axis.		Ends turned flat and parallel to each other.		Ratio of strength.
			Mean break. weight of Pillar in tons.	Mean break. weight per sq inch in tons.	Mean break. weight of Pillar in tons.	Mean break. weight per sq. inch in tons.	
60·5	·50	121·00	·0638	·325			
60·5	·51	118·62			·2174	1·063	
60·5	·77	78 59	·3482	·747	1·0964	2·354	3·14
60·5	·99	61·11	·8491	1·102			
60·5	·997	60·68			2·7848	3·566	
30·25	·50	60·50	·2406	1·225	·7419	3·778	3·08
90·75	1·72	52·76			9·8191	4·225	
90·75	1·76	51·56			10 3477	4·253	
60·5	1·29	46·89	2·5477	1·949	7 1714	5·486	2·81
90·75	2·24	40 51	9·5004	2 410			
60 5	1·535	39·41	4·7544	2·568			
60·5	1·54	39·28	4·9906	2 679			
30 25	·77	39·28	1·2169	2 613	3·9334	8·446	3·23
60·5	1·55	39·03			12·6575	6·708	
30·25	·99	30·55	2·7254	3·540			
30·25	1·01	29·95			9·0669	11·315	
15·125	·76	19·90	4 3508	9 590	8·4834	18·700	1·94
20·1666	1·02	19 77	7·0254	8·706			
20·1666	1·022	19·73			14·6446	17·307	
15·125	·77	19·64	4·5258	9·719	9·9834	21·438	2·20
15·125	·99	15·27	8·8178	11·454			
15·125	1·00	15 12			17·9687	22·878	
10·083	·76	13·26	7·8151	17·229	11·3325	24·983	1·45
10·083	·77	13 09	8·5500	18·363	11·3977	24·479	1·33
7·5625	·77	9 82	10·2446	22·002	13·9263	29·910	1·35
3·7812	·50	7·56	6·7441	34·347	7 7982	39·715	1·15
2·	·52	3·84			10·2084	48 068	
1·	·52	1·92			10·9892	51·745	

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9 \frac{D^{3\cdot76}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formulæ, $W = 14{\cdot}9 \frac{D^{3\cdot76}}{L^{1\cdot7}}$. $Y = \frac{Wc}{W + \frac{3}{4}c}$.	Calculated breaking weight per square inch in tons.	Ratio of strength of pillars of same dimensions with *flat* ends.
5	2	30	13·08		4·16	2·56
8	"	48	5 88		1·87	2 56
14	"	84	2·27		0 72	2·56
20	"	120	1·23		0·39	2 57
5	2½	24	30 23		6·15	2·31
6	"	28·8	22·17		4·51	2·45
5	3	20	60·10		8·50	2·03
6	"	24	44·08		6·23	2·24
7	"	28	33·92		4 79	2 35
8	"	32	27·03		3·82	2·35
14	"	56	10·43		1 47	2·35
20	"	80	5·69		0 80	2·35

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9 \frac{D^{3.76}}{L^{1.7}}$.	Calculated breaking weight in tons from formulæ, $W = 14{\cdot}9 \frac{D^{3.76}}{L^{1.7}}$ $Y = \frac{W c}{W + \frac{3}{4} c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars, same dimensions, with *flat* ends.
5	$3\frac{1}{2}$	17·142	107·31		11·15	1·79
6	"	20·571	78·71		8·18	2·01
7	"	24	60·56		6 29	2·18
8	"	27·428	48·26		5·01	2·27
5	4	15		170·80	13·59	1·65
6	"	18	130·03		10·34	1·81
7	"	21	100·05		7·96	1·99
8	"	24	79·73		6·34	2·13
9	"	27	65 26		5·19	2·21
10	"	30	54·56		4·34	2·21
20	"	60	16·79		1·33	2·21
5	$4\frac{1}{2}$	13·333		249·99	15·72	1·57
6	"	16		200·51	12·61	1·66
7	"	18·666	155·80		9·79	1·82
8	"	21·333	124·16		7·80	1·97
9	"	24	101·63		6·39	2 09
10	"	26·666	84·96		5·34	2·16
11	"	29·333	72·25		4·54	2·16
5	5	12		348·73	17·76	1·50
6	"	14·4		280·40	14·28	1·60
7	"	16·8	231·54		11·79	1·67
8	"	19·2	184·52		9·39	1·82
9	"	21·6	151·04		7·69	1·95
10	"	24	126·27		6·43	2·05
11	"	26·4	107·38		5 46	2·11
12	"	28·8	92 61		4·71	2·11
20	"	48	38·86		1·97	2·11
5	$5\frac{1}{2}$	10·909		468 04	19·70	1·44
6	"	13 090		384·51	16·18	1·53
8	"	17·454	264·05		11·11	1·69
10	"	21·818	180·69		7·60	1·93
12	"	26·181	132·53		5·57	2·07
5	6	10		608·69	21·52	1·39
6	"	12		505·68	17·88	1·47
7	"	14		424·85	15·02	1·54
8	"	16		361·06	12 77	1·60
9	"	18	299·79		10·60	1·70
10	"	20	250·62		8·86	1·81
11	"	22	213 14		7·53	1·91
12	"	24	183 83		6·50	1·99
13	"	26	160 44		5·67	2·03
14	"	28	141 45		5·00	2·03
15	"	30	125·80		4·44	2·03
20	"	40	77·13		2·72	2·03

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$.	Calculated breaking weight in tons from formulæ, $W = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$ $Y = \frac{W c}{W + \frac{3}{4} c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars, same dimensions, *rounded* ends.
5	2	30	33·52		10·66	2·56
8	"	48	15 07		4·79	2·56
14	"	84	5·82		1·85	2·56
20	"	120	3·17		1·00	2·57
5	2½	24		69·99	14·25	2·31
6	"	28·8	54·32		11·06	2·45
5	3	20		122·08	17·27	2 03
6	"	24		98·83	13·98	2·24
7	"	28	79·81		11·29	2·35
8	"	32	63·60		8·99	2·35
14	"	56	24·56		3·47	2·35
20	"	80	13·39		1·89	2·35
5	3½	17·142		192·70	20 03	1·79
6	"	20·571		158·62	16·48	2·01
7	"	24		132·32	13·75	2·18
8	"	27·428	109·95		11·42	2 27
5	4	15		282·98	22·51	1·65
6	"	18		236·53	18·82	1·81
7	"	21		199·68	15 88	1·99
8	"	24		170·35	13·55	2·13
9	"	27	144·58		11·50	2·21
10	"	30	120·87		9·61	2·21
20	"	60	37·20		2·96	2·21
5	4½	13·333		393·64	24·75	1·57
6	"	16		333·64	20·98	1·66
7	"	18·666		284·84	17·91	1·82
8	"	21·333		245 20	15·42	1·97
9	"	24		212·86	13·38	2·09
10	"	26·666	183·62		11·54	2·16
11	"	29·333	156·15		9·82	2·16
5	5	12		525·14	26 74	1·50
6	"	14·4		450·75	22·95	1·60
7	"	16 8		388·84	19·80	1·67
8	"	19·2		337·58	17·19	1·82
9	"	21·6		295·11	15·02	1·95
10	"	24		259·78	13·23	2·05
11	"	26·4	226 98		11·55	2·11
12	"	28·8	195·77		9·97	2·11
20	"	48	82·15		4·18	2·11
5	5½	10·909		677·69	28·52	1·44
6	"	13·090		588·36	24·76	1·53
8	"	17·454		448·45	18·87	1 69
10	"	21·818		349·36	14·70	1·93
12	"	26 181	274·60		11·55	2 07

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Flat, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16 \frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formulæ, $W = 44{\cdot}16 \frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$. $Y = \frac{W c}{W + \frac{3}{4} c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars of same dimensions with *rounded* ends.
5	6	10		851·39	30·11	1·39
6	"	12		746·79	26·41	1·47
7	"	14		656·17	23·91	1·54
8	"	16		578·56	20·46	1·60
9	"	18		512·41	18 12	1·70
10	"	20		456 04	16·12	1 81
11	"	22		407·91	14·42	1·91
12	"	24		366·66	12·94	1·99
13	"	26	326·40		11 54	2·03
14	"	28	287·76		10·17	2 03
15	"	30	255 92		9·05	2 03
20	"	40	156·93		5·55	2·03

Solid Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Side of the square in inches.	Number of diameters contained in the length or height.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formulæ, $W = 10{\cdot}95 \frac{D^4}{L^2}$ $Y = \frac{W c}{W + \frac{3}{4} c}$.
5	8	7·5	2·222	104·83	202·19
6	"	9	2·666	125·79	194 94
7	"	10·5	3·110	146 76	187·01
8	"	12	3 555	167·73	178·63
9	"	13·5	3·999	188·69	170·00
10	"	15	4·444	209 66	161 29
11	"	16·5	4 888	230·63	152 64
12	"	18	5·332	251·59	144·18
13	"	19·5	5·777	272·56	135 98
14	"	21	6·221	293 52	128·11
15	"	22 5	6·666	314·49	120·62
16	"	24	7·110	335·46	113·52
17	"	25·5	7 554	356 42	106·83

Solid Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 7{\cdot}81 \frac{D^4}{L^2}$ $Y = \frac{W c}{W + \frac{3}{4} c}$.
5	8	7·5	2·222	96 76	169 46
6	"	9	2·666	116·12	162·37
7	"	10·5	3·110	135·47	154·71
8	"	12	3 555	154·82	146·73
9	"	13·5	3·999	174 18	138·62
10	"	15	4·444	193·53	130·56
11	"	16·5	4·888	212 88	122·67
12	"	18	5·332	232·24	115·06
13	"	19 5	5·777	251·59	107·79
14	"	21	6·221	270·95	100·90
15	"	22·5	6 666	290·30	94·42
16	"	24	7·110	309·65	88·36
17	"	25 5	7·554	329·01	82 71

(To be Continued.)

On Benson's High Pressure Steam Boiler. By Mr. John James Russell, of Wednesbury.

From Newton's London Journal, September, 1861.

The boiler forming the subject of the present paper, the invention of Mr. Martin Benson, of Cincinnati, U. S., was described at a former meeting of the Institution, in a paper giving the particulars of the application and working of a number of these boilers in America, where they have been in operation from three to four years; about fifty of them being in use for various purposes.

A boiler of this construction having since been erected at the writer's works at Wednesbury, and having now worked satisfactorily for ten months, the further results are given in the present paper. This boiler has been in constant work, driving an engine of 60 indicated horse power; and so thoroughly satisfied was the writer with the results, and the correctness of the principle upon which the boiler is constructed, that he has since erected a second and larger one upon the same plan, but with some improvements in the details, resulting from experience derived from the former boiler. This boiler is now at work on the same premises.

The boiler proper is composed entirely of serpentine tubes, arranged in sections in a vertical plane over the fire. At the front and back of the boilers are doorways for fixing, disconnecting, and taking out the tubes. A circulating pump draws its supply of water from a water and steam receiver, and is worked by a small donkey engine. The lowest tubes of each section of the boiler are connected to the main supply pipe from the circulating pump. The top tubes of each section are joined to the main delivery pipe, and into it the water and steam together are delivered from the tubes, and thence discharged into the upper part of the steam receiver.

The circulating pump is a simple direct-acting pump, with a metallic packed piston, constructed with a single slide valve, instead of suction and delivery valves, so that it is certain and constant in its action; the slide valve is made without any lap or lead, and thus agrees exactly with the motion of the piston. The pump draws its supply of water from the receiver, through the ordinary exhaust port running round the cylinder, and discharges it into the tubes through the main supply pipe. The steam generated in the tubes is driven up with the water through the tubes, and discharged through the delivery pipe into the receiver, where the steam and water are separated; and the water is then again taken by the circulating pump, and returned into the tubes. In starting the boiler, the receiver is supplied with water until its level reaches the fifth or sixth row of tubes from the bottom. As the circulating pump is standing still at first, in consequence of having no steam to work it, the slide valve is allowed to be lifted off its face by the pressure of the water, and lets the water flow past the pump direct through into the tubes. The fire is then lighted, and steam raised from the water in the tubes, which starts the circulating pump to work.

More water is forced through the tubes by the circulating pump than is evaporated in them. The circulating pump of the boiler now used for ten months is double-acting, 6 ins. in diameter, with 9 ins. stroke, and makes 40 revolutions per minute, against a resistance of from 7 to 10 lbs. pressure per square inch; the power required to work it is therefore about $\frac{1}{2}$ horse power, including the friction of the pump. At this speed, it forces through the boiler from 9 to 11 times as much water as is evaporated, which has been found too much to get the greatest efficiency of the boiler; and from 6 to 8 times the quantity evaporated is considered about the proper proportion. In this instance, owing to the construction of the donkey engine, the pump cannot be worked at less than 40 revolutions per minute, at which speed it is fully capable of supplying a 100 horse power boiler at ordinary working pressure, instead of one of only 60 horse power. With high pressure steam, superheated and worked expansively, the pump is large enough for a 150 horse power boiler, in which case $\frac{1}{3}$d per cent., or $\frac{1}{300}$th of the whole power produced is all that is required for working the circulating pump; and with the improved circular bends that have now been adopted for uniting the ends of the tubes in the boiler, there is reason to expect the circulation can be maintained with much less power. No more power is required to work the pump with 80 and 100 lbs. steam than with 20 lbs., since the pressure is the same on both sides of the piston, and the only resistance to be overcome is the friction of the water in the tubes, which of course is increased in proportion to the speed; with the boiler now at work, the resistance on the piston at the proper speed, does not exceed 7 to 10 lbs. per square inch. Originally, the delivery pipe into which the steam and water from the tubes are discharged, was only 5 inches diameter inside, which was found too small; in the present boiler, it has been made 10 ins. diameter. The receiver is supplied with feed water by one of Giffard's injectors, instead of an ordinary feed pump.

It was originally supposed that the mechanical circulation of the water with 9 to 11 times more water forced through the tubes than is evaporated, would be sufficient to prevent deposit, by keeping them washed out clean; and this is the case to a certain extent, as all loose matter is washed by the circulation from the tubes, into the receiver. Some incrustation, however, does take place, but not sufficient to present any practical difficulty, or cause any damage to the tubes. One of the tubes from the first boiler is exhibited as a specimen, showing the amount of deposit that has been formed during the ten months it has been in use. The deposit is greatest in the lower tubes of the boiler, and decreases in the upper rows: practically it is prevented from accumulating so thick as to cause the tubes to be injured by the heat; since it becomes cracked and loosened from the tubes, by their alternate expansion and contraction under the varying temperature of the fire. At times, also, nearly all the water is worked out of the tubes, so as to let them get hot, but not hot enough to cause injury by over-heating; and when the deposit is thus loosened in the tubes, it is washed out into the receiver, by the circulation of the water. The

dirt and scale are cleared out of the receiver by a blow-off cock, which is opened for blowing off two or three times a-day. It takes about a quarter of a minute to free the blow-off cock from the deposit lodged in the receiver, before a full body of water issues from it. Pieces of deposit are blown off which have a circular form, showing that they have been formed in the tubes, and then scaled off and washed into the receiver. The semicircular form of the bends uniting the ends of the tubes, prevents any incrustation lodging in them, by giving an unobstructed passage.

The mode of uniting the tubes together in the former boilers of this construction was with right and left handed screws cut on the ends of the tubes, and screwed into the bends; but this make required an entire section of the boiler to be taken out when a new tube had to be put in; and with large boilers this is too much trouble, owing to weight, difficulty of handling, and impossibility of unscrewing many of the tubes in the bends after they have once been screwed up and put to work. To meet these difficulties, a new form of bend has been made in the present boiler, which admits of any one of the tubes in any part of the boiler being taken out, without removing that section of the boiler, or interfering with any other joints than those of the tube to be removed. Thus, instead of screwing the ends of the tubes, they are made with collars of suitable size welded on, and the ends of the bends are recessed out to receive them: the bends are brought up tight against the collars on the tubes by a centre screw bolt, which passes through a hole in the bend in line with the centres of the two tubes, and is screwed into a cross-bar bearing against the outside face of the collars. The passage through the bend is made on one side of the fixing bolt, to prevent it from obstructing the flow of steam and water. By this plan any of the bends can be taken off through the doorways at the front and back of the boiler, and any tube can be taken out and replaced. The ends of the tubes are passed through end bearing plates, which serve also as shield plates to protect the cast iron bends from the heat of the fire; these plates rest on the walls of the furnace, or are suspended at the top from girders. The joining of the tubes to the main supply and delivery pipes is also effected by collars upon the ends of the tubes fitting into recesses in the main pipes and held up tight by a cross-bar and stud-bolt. By having valves for cutting off the communication between the receiver and tubes, the steam and water can be retained in the receiver during the time of removing a tube; and when distilled water from the surface condenser is used in the boiler, the water can, by this means, be saved if the tube should burst, and be shut off from the boiler while the repairs are in hand.

The special advantage of this boiler is, that steam of high pressure is generated in it with greater safety than steam of low pressure in ordinary boilers. Its construction insures almost perfect safety: for the receiver, the only portion containing any quantity of steam and water capable of causing damage by explosion, is of the strongest form for resisting pressure, of simple construction, and removed from the action of the fire, so that it is entirely free from the injurious

effects of over-heating, and the alterations of expansion and contraction, which are considered to be the cause of so many injuries and explosions of ordinary boilers. The only portion of the boiler exposed to the fire is the tubes, which are of such small capacity that their explosion is incapable of doing any damage, and can only cause the fire to be put out by the water escaping from them. This has been confirmed by the experience with the boiler at the writer's works, where a tube has burst on more than one occasion whilst the boiler and engine were at work; and the effect was so small, that the accident was not immediately perceived, until shown by the loss of steam pressure; the steam and water blowing out upon the fire through the leak in the split tube, and putting it out. The advantages of high pressure steam are now generally recognised; but a much higher pressure than can be obtained in ordinary boilers and superheating of the steam are required to develop these advantages fully, by cutting off the steam earlier with a higher degree of expansion. The economy of expansion is now limited by the weakness of boilers in general use; and a large increase of economy may be obtained if much higher pressures can be safely used.

The leading feature of this boiler is the use of the circulating pump, to maintain a constant and regular circulation of the water through the entire set of tubes forming the heating surface of the boiler. This principle of mechanical circulation is found essential in order to carry out completely the idea of a tubular boiler, in which the heating surface consists entirely of the tubes having the pressure internal, and thereby attaining a maximum of strength and safety with a minimum of material. The rapid generation of steam in the lower portion of such a boiler would so far choke the passage of the tubes as to check the natural circulation of the water, and cause the tubes to be rapidly burnt out. The objection arising at first against the adoption of artificial or forced circulation instead of natural—that it is not self-acting, and may therefore be liable to cause interruption to the working of the boiler—has been satisfactorily proved by the results of the continued working of this boiler to be practically met by the simplicity of construction of the circulating pump previously described. During the ten months that the boiler has been in continual work, this pump has always worked well, and never given any trouble except from causes foreign to its principle of working, such as the water freezing in it, and breaking it. In first raising steam in the boiler, no difficulty is experienced from the circulating pump not being at work, since the tubes do not require circulation of the water until steam is raised, and the pump then starts with a small pressure of steam, so little power being required to work it.

The portability of this boiler is an important practical advantage for several cases of application. The largest piece, the receiver, is only one-tenth the size of an ordinary boiler of the same power, and the tubes can be packed in bundles, giving great advantage for shipping over other boilers, both in the reduction of total weight and in the increased facility for stowage. The economy of space is very great,

and an important advantage in many situations where space is limited and valuable; the space occupied being only one-sixth to one-fourth of that required for ordinary Cornish or cylindrical boilers of the same power.

Owing to the duplication of parts in its construction, the cost of the boiler is but little more than that of ordinary boilers above 25 horse power, including the circulating pump and all the mountings. A small boiler of the kind costs more in proportion than a large one; for in all cases it is best to have an independent circulating pump, and a small pump costs nearly as much as a large one. In this comparison, it is supposed that the steam is worked at the ordinary pressures in both cases, say from 25 to 50 lbs. per square inch; but the suitable working pressure for the new boiler is 100 to 150 lbs. per square inch, with the steam superheated and worked expansively; when thus worked and compared with other boilers in first cost per horse power, the new boiler is much cheaper, and in all cases far cheaper for transporting and setting in masonry. The average thickness of the boiler tubes is not more than $\frac{1}{8}$-inch, and their whole surface is effective heating surface; this results in a great saving of weight compared with ordinary boilers with plates $\frac{3}{8}$ to $\frac{1}{2}$-inch thick. In comparison with marine boilers, the new boiler can be made much cheaper than those on the ordinary mode of construction, while the facility for repair gives a decided advantage.

Though the steam and water from the tubes are discharged together into the receiver, there is a complete separation of them, and there has not been the least trouble from priming. More fully to prove the fact of their separation, cocks have been placed on the upper and lower sides of the delivery pipe leading from the tubes to the receiver: from the upper cock nothing but steam was found to issue, and from the lower nothing but water; and supposing priming to be caused by taking steam from boilers exposed to the direct action of the fire, it is effectually prevented in this boiler for the reason that no fire acts upon the receiver containing the water, from which the steam is taken off, and consequently the water remains in a quiet state. Superheating of the steam is effected by returning the steam from the receiver back to the furnace, and passing it through a sufficient number of superheating tubes, whence it is taken off by a steam pipe to the engine. The superheating tubes are arranged and united together in the same manner as the boiler tubes, and are consequently as simple and convenient to get at for erecting and repairing.

The evaporative duty of the boiler with Staffordshire slack has been $5\frac{1}{2}$ lbs. of water per pound of fuel, without covering the receiver and steam pipes to prevent condensation. Steam has been raised from the time the first shovel of fire was placed in the furnace when cold, without wood or forced draft, to 10 lbs. pressure in twenty-five minutes, when the steam was sufficient to start the circulating pump; in ten minutes more there was 35 lbs. pressure of steam, when the engine was started; and in ten minutes more, being forty-five minutes from the time the first shovel of fire was put in the furnace, all the ma-

chinery driven by the engine was in operation, and there was sufficient steam to produce all the power required. This was with only $\frac{7}{10}$ths of the boiler, or 460 square feet of heating surface, $\frac{3}{10}$ths of the boiler being then not at work. The practice at dinner hours and other times when the engine is stopped, has been to close the damper, open the fire doors, and cover the fire with ashes and slack, and work the circulating pump as slowly as its construction will permit; this entirely prevents generation of steam, and in the meantime saves the tubes from overheating. For starting the engine again, the fire is stirred up, and supplied with coals five or ten minutes before steam is wanted; which is ample time to generate a regular and sufficient quantity of steam to commence working all the machinery driven by an engine of 60 horse power. Steam can be regularly maintained in the boiler that has now been in use for ten months, with a variation of from 10 to 15 ℔s. pressure when all the work is on the engine with 40 to 55 ℔s. steam in the boiler. The pressure cannot be maintained with quite the same regularity in this boiler as in ordinary boilers, on account of the comparatively small amount of steam room; at the same time it is found that a sufficient quantity of steam is made with regularity enough for all practical purposes.

For the purpose of insuring that the pressure of steam supplied to the engine shall never exceed the intended limit, and of preventing any risk of injury to the engine by over pressure arising from the comparatively small steam room in the boiler, the writer designed a regulating valve, which has been found to fulfil this object with complete success. It consists of a double-beat valve, having a piston below it fixed upon the same spindle, and of the same area as the lower valve, and supported by a spiral spring, which presses the valves open. The steam from the boiler, passing through both the valve seats, is delivered to the engine by a supply pipe; at the same time it acts upon the top of the piston, compressing the spiral spring below to a greater or less extent, according to the pressure of the steam; thus partially closing the valve and wire-drawing the steam whenever its pressure at entrance approaches the intended limit. The spiral spring is adjusted so as to hold the valve full open until this limit of pressure is nearly reached; but whenever that takes place, the partial closing of the vale checks the supply of steam, and prevents the pressure of the steam supplied to the engine from rising above the intended amount. The bottom of the spiral spring is carried by a cylindrical cap, sliding vertically, and supported by the end of a weighted lever, which is adjusted to balance the pressure on the piston at the limit of steam pressure. As soon as the intended pressure is exceeded, this lever is depressed immediately, closing the valve entirely, and shutting off the supply of steam. A safety valve is added on the top of the casing, to make the precaution complete. This regulating valve is in constant work, and maintains the steam supplied to the engine at a uniform pressure. It may also be applied with advantage to low pressure and high pressure engines working in connexion, serving completely to regulate the limit of pressure of the steam supplied to the low pressure engine.

Mr. Russell exhibited specimens of the joints and bends of the boiler tubes, and some of the burst and incrusted tubes that had been taken out of the boiler, as described in the paper.

Mr. J. Fenton observed, that the evaporative duty shown by the boiler was low, amounting to only 5½ lbs. of water per pound of slack.

Mr. Russell said, the boiler was at present very unfavorably circumstanced as to evaporative duty, owing to the steam pipes and receiver not being protected in any way, and much heat from the fire was also lost by passing away into the chimney. The advantage to be obtained by the new boiler in economy of fuel would be fully shown when steam of very high pressure was used, which could be safely done only with a boiler upon that construction.

Mr. G. A. Everitt thought that the consumption of 18 tons of slack per week for an engine of 60 indicated horse power was certainly far from economical; for with Cornish boilers he was burning at his works only 16 tons of slack altogether per week for two engines of 60 nominal horse power, working up to 170 indicated horse power.

Mr. W. Richardson mentioned, that in Green's economizer, which he had used for several years past for heating the feed water by the waste heat passing to the chimney, consisting of a stack of upright pipes placed in the chimney flue, through which the feed water was passed on its way to the boiler, cast iron pipes were first used, but they had tried substituting wrought iron pipes to obtain a thinner metal, that would conduct the heat better; these, however, all became riddled through with small holes in eighteen months, by the destructive action of the condensed water, and had all to be taken out again, and replaced by cast iron pipes. The same result had been experienced at several other places where wrought iron pipes had been tried in the economizer; and he feared therefore the wrought iron tubes in the boiler would be destroyed in the same way by their direct exposure to the fire.

Mr. Russell said there had been such long experience of the use of wrought iron tubes in boilers, that there was no fear for their durability, and they had been found to last for many years working with regular circulation through them. With respect to the degree of superheating obtained, he said that, at 60 or 70 lbs. pressure, the steam was superheated about 220° or 240° by passing through the superheating tubes; and after taking out three sections of the boiler tubes, the steam was superheated more than 500°, having a temperature of more than 900° after passing through the superheating tubes, in consequence of their having in that case a greater extent of surface exposed direct to the fire, while less of the heat was taken up by the boiler tubes.

Mr. C. W. Siemens observed, that the amount of superheating which had been mentioned would go far to explain the low evaporative duty of the boiler; for if the steam were superheated to upwards of 900° by the superheating tubes in their present position close to the chimney, the heat passing away into the chimney must be more than 1000°, which would produce a great loss of fuel. The tubular construction

of boiler, in which the entire heating surface consisted of small tubes, having great strength to resist internal pressure, was, he thought, one that might be advantageously employed, and it had been tried in this country by Dr. Alban many years ago, with steam of 150 to 200 lbs. pressure. In the present boiler, the circulating pump was the novel feature, producing an artificial circulation of the water through the tubes; but he questioned the desirability of introducing such a system, on account of the additional complication involved, and thought the plan might be simplified by some alteration in the arrangement, so as to rely on natural circulation alone.

Mr. Benson said, the special feature of the boiler was the forced circulation of the water, to prevent the tubes ever being short of water; he was satisfied that a boiler of this construction would not last more than five or six months, were it not for the mechanical circulation; for the tubes would soon tear themselves to pieces by unequal expansion and contraction, if exposed to the risk of being alternately full and empty of water, which they would be liable to, if dependent on natural circulation. In the case of water heaters that had been referred to, the tubes were soon eaten through by corrosion, and became forced out of position and twisted round, owing to the small quantity of water passing through them; but no such results had been experienced in the tubes of the boilers, because the quantity of water passed through them by the forced circulation was so much greater than that evaporated. The bottom tubes were made $1\frac{1}{4}$ inches diameter for one-third the height of the boiler, then $1\frac{1}{2}$ inches for the next third, and $1\frac{3}{4}$ inches at the top, which gave an additional security for the bottom tubes being always thoroughly filled with water, while greater freedom of passage was allowed at the top for the mixed water and steam escaping into the receiver.

The chief improvement made since the erection of the first boiler on this construction was, the mode of fixing the tubes in such a manner as to allow of removing and replacing any tube, without taking out an entire section of the boiler: a tube could now be taken out, and a new one put in, in as short a time as 15 to 20 minutes, when the boiler was again ready for work at once.

When the boiler was properly constructed, he had found the evaporative duty was equal to that of any tubular boiler; but in the present instance the boiler was not working under favorable circumstances for economy of fuel. The sections of the boiler were set $1\frac{1}{2}$ inches apart, and much heat escaped between them direct into the chimney. The draft was also deficient, the chimney being only 2 feet diameter, which was too small for the purpose; so that there was not air enough drawn in for thorough combustion of the coal, and smoke generally issued from the chimney for a short time after firing.

A number of air-holes were made in the brick-work on all sides of the furnace, but these were not sufficient to prevent smoke, without a greater force of draft.

Proceedings Mech. Eng. Society.

On Electrical Quantities and Resistance.

From the London Mechanics' Magazine, September, 1861.

A paper, prepared by Mr. Latimer Clark and Sir Charles Bright, "On the principles which should be observed in formation of standards of measurement in electrical quantities and resistance," was read by Mr. Latimer Clark. He said the science of electricity, and the art of telegraphy, have both now arrived at a stage of progress at which it is necessary that universally received standards of electrical quantities and resistances should be adopted, in order that precise language and measurement may take the place of the empirical rules and ideas now generally prevalent. Several standards of resistance have already been proposed, but none have as yet come into universal use, and they have all the disadvantage of being arbitrary in their derivation, or of having no relation to other electrical quantities and measurements. Four electrical standards or units are in reality required; these are mutually dependent on each other, and by their aid every conceivable form of electrical manifestation, whether static or dynamic, and whatever its origin or quantity, can be precisely and definitely stated. They are as follows:—

A. A unit of electrical tension, potential, or electromotive force.

B. A unit of electrical quantity, as applied to static electricity.

C. A unit of electric current, or quantity as applied to dynamic electricity.

D. A unit of electrical resistance.

A.—*The Unit of Electrical Tension, or Electromotive Force.*

It is probable that no more convenient unit of tension could be found than that of a single cell of a Daniell's battery; its electromotive force is but little dependent on temperature, or the strength of solutions, while the continued deposit of fresh and pure copper makes its force remarkably constant. It is moreover a standard which is in constant use, and its energy is so inconsiderable that it would not often require defining fractionally in practice. It is, however, possible to find a more elementary unit. Recent researches have shown, for example, that if a piece of pure zinc be placed in contact with water, or an oxidizing acid, the zinc oxidizes, and in doing so instantly gives off electricity, thereby lowering its own tension, and raising that of the liquid. As soon as the two have acquired a certain definite and constant difference of tension, the oxidation ceases, and the zinc is no longer attacked. If a piece of copper, or silver, or other less oxidizable metal, be placed in mutual contact with the zinc and the liquid, so as to afford a path for the equalization of the tension, the solution goes on constantly, and the continual flow of the electricity from the liquid to the zinc, through the pathway afforded by the copper, forms what is termed a voltaic current. All oxidizable metals have their own specific limit of tension at which they cease to be oxidized, and any of these tensions might be chosen as a unit, but without any practical advantage over that afforded by the Daniell's element. It is scarcely necessary to remark, that the unit of tension is equally applicable to

static electricity, and to the tensions existing at different points in an electric current. The zero of tension is naturally that of the earth at the place and time being, and the degree may be either plus or minus.

B.—*The Unit of Absolute Quantity as applied to Static Electricity.*

There is no natural guide for the formation of this important unit (which is the foundation for the two following), and it is therefore necessary to fix on an arbitrary one. It is well known that the quantity of static electricity—that is, electricity under induction—varies, *cœteris paribus*, directly as the difference of tension between the induced and inducing surfaces. The quantity is also dependent on two other conditions, the difference in the surfaces from each other, and the nature of the interposed dielectric. Let us, for the sake of argument, assume the dielectric to be dry air, the difference of tension to be equal to that of one element of Daniell's battery, the surfaces to be one millimetre, as under, and the area to be one square metre; such a standard would be an arbitrary but not an inconvenient one, and to this unit we could refer all other quantities. In practice this unit would require multiplication by one thousand and by one million. Under this head it is important to observe that any quantity of electricity has a definite existence quite independently of its tension, and when once placed in a body the tension may be raised or lowered or annihilated, or even reversed in its sign from plus to minus, without any change in its quantity; and when the disturbing causes are removed the quantity remains as before.

C.—*The Unit of Electricity in Motion, or Electric Current.*

Having formed a unit of quantity, the definition of this standard becomes simple and obvious; it is formed by a combination of quantity with time. Thus one unit of electricity passing her second naturally forms a unit of current. The practical formation of this standard presents few difficulties. It has been shown by Messrs. Siemens, that when a uniform succession of rapid discharges is sent through a galvanometer, the deflection of the needle is constant and steady. It is easy, therefore, to send a given number of units per second through a galvanometer, and to compare the deflection obtained with that produced by a constant current from a voltaic couple through a given resistance. This method of determining the standard of conductivity has the advantage of being quite independent of resistances. Although it has not yet been put to the test of experiment, there is no reason to doubt that a given quantity of electricity per second will produce an equal deviation of the galvanometer, whether it flow in a continuous stream or in a succession of minute impulses.

D.—*The Unit of Resistance.*

The standard or unit of resistance should necessarily be the same as that of conductivity, or current—that is to say, a wire that will conduct one unit of electricity in one second of time. This would be a very convenient unit for expressing the resistance of the materials used for covering telegraph cables, but would be much too large for defining the resistance of telegraph conductors, and it would require

subdivision by 1000 and 1,000,000, and these resistances would correspond to wires capable of conveying 1000 and 1,000,000 units of current respectively—that is, wires which would, at the usual degree of tension, conduct 1000 and 1,000,000 units of electricity per second. The value of this mutual relationship and dependence will be seen more clearly if we assume a nomenclature for these units, and for this temporary purpose we will derive terms from the names of some of our most eminent philosophers, neglecting for the moment etymological rules. We shall then have the following table :—

A.—*Tension.*

1 Daniell's Element, .	= 1 Ohma, or unit of tension.
1000 Ohmas . .	= 1 Kilohma.
1000 Kilohmas . .	= 1 Milliohma.

B.—*Quantity.*

1 Ohma, by 1 metre square at 1 Milliometre distance	= 1 Farad, or unit of quantity.
1000 Farads . . .	= 1 Kilofarad.
1000 Kilofarads . .	= 1 Milliofarad.

C.—*Current.*

1 Farad per second . .	= 1 Galvat, or unit of current.
1000 Galvats . .	= 1 Kilogalvat.
1000 Kilogalvats . .	= 1 Milliogalvat.

D.—*Resistance.*

1 Farad per second, . .	= 1 Volt, or unit of resistance.
1-1000 Volt . . .	= 1 Kilovolt.
1-1000 Kilovolt, . .	= 1 Milliovolt.
1-1000 Milliovolt . .	= 1 Billiovolt.

The ohma, or unit of tension, is practically a very convenient one for all battery purposes: lower tensions, though not often required, may be readily defined fractionally. The kilohma, or the tension of 1000 Daniell's cells, is a convenient one for static electricity and for that of induction coils, as it will pass across a small interval of air. The milliohma is applicable to static electricity of very high tension. The farad, or unit of quantity, is as small a one as is likely to be required in practice. 70 feet of ordinary telegraph wire, with a tension of one cell, would contain about a farad of electricity; 100 farads, if allowed to pass through a very sensitive galvanometer, produce a visible motion of the needle. The kilofarad is a good unit for defining the charge or inductive capacity of submarine cables. The volt, or unit of resistance, is represented by a wire, which would, with a tension of one element, convey a current of one galvat—that is, one farad per second. It would be a useful measure of the resistance of the insulating covering of single miles of cable, although there are some of the most perfect modern cables which offer a still higher resistance. It is, however, altogether too large a unit for the resistance of metallic conductors; it is therefore subdivided into the kilovolt and milliovolt, which last measure is probably small enough to be applicable to the resistances of the conductors of ordinary telegraphic cables. For still smaller resistances it is necessary to have recourse to the billiovolt. The mutual relation and dependence of these units is seen at a glance; thus, at the normal tension, a wire having a resistance of 1 volt, will

conduct 1 farad of electricity per second, or give a current of 1 galvat, and similarly a wire having a resistance of 1-10 kilovolt will give a current of 10 kilogalvats, that is, 10 kilofarads per second; if the tension be doubled or tripled, the quantities will be increased in the same proportion.

The practical introduction of this, or some similar system of notation, would be so great a boon to science and to the art of telegraphy, that it is hoped the British Association will lend its assistance and authority for the settlement of the question, and it is suggested that a committee, composed of members of the Association, should be delegated to examine and report on the whole question at the next annual meeting, with power to confer with English or foreign philosophers, and that funds should be provided for the preparation of standards for public use and reference, a duty in which they would meet with the hearty co-operation and assistance of practical electricians.

Proceedings British Association.

New Marine Glue.

From the Lond. Mechanics' Magazine, September, 1861.

Mr. William John Hay, of Portsmouth Dockyard, has patented his new composition for coating vessels, &c., by permission of the Admiralty, and a company is established for manufacturing it.

The composition is much cheaper than marine glue, and, consequently, cannot fail to be largely adopted by the shipping interest generally. In addition to the purposes to which ordinary marine glue is applicable, the water-proof glue, from its extremely low price, may be used for caulking and paying the seams and decks of all classes of vessels, and will, consequently, become a substitute for the costly marine glue and the inexpensive pitch. Indeed, the purposes for which the glue may be used are almost innumerable; it will be found the cheapest and most durable application for iron, wood, and all other descriptions of roofing and fencing, a good substitute for bottling wax and metallic capsules, and a desirable covering for posts, piles, &c. The glue has been tested by seven years trial, and found to answer the most sanguine expectations. For the information of those who have not proved the superiority of the water-proof glue by actual use, it may be stated that its principal ingredient is Trinidad pitch, or asphalte, which is mixed with vegetable tar and oil naphtha, or a suitable substitute. The best proportions for the ingredients which Mr. Hay has yet discovered are—Trinidad pitch, or asphalte, 60 lbs.; vegetable tar, 15 lbs.; oil naphtha, 2 lbs. Instead of the oil naphtha, $2\frac{1}{4}$ lbs. of rough creosote, or 4 lbs. of oil of turpentine may be used. In cases where it is required to pack the composition, and send it out for use, and where it may be expected to require remelting and long exposure to heat in the melting pots while being used, he adds an additional $\frac{1}{2}$ lb. of oil naphtha, rough creosote, or oil of turpentine. For paying seams in ships' sides or other upright or nearly upright structures with mops or brushes, a more fluid kind of composition is necessary, which may be obtained by adding to each 20 lbs. of the compo-

sition half a pint of reducing liquid; this liquid is also used to thin down the pitch when long exposure to heat has evaporated a proportion of the vegetable tar and oil. The reducing liquid is composed of vegetable tar 12 lbs., and oil of naphtha (in which $\frac{1}{2}$ oz. india-rubber has been dissolved) 3 lbs. For the oil of naphtha, 3 lbs. rough creosote or 5 lbs. oil of turpentine may be substituted, but the first mixture is preferred. The pitch and tar are heated separately, and well mixed; the oil is then added, and the composition is ready for use.

On Superheating Steam. By L. E. Fletcher, Chief Eng.

From the Lond. Mechanics' Magazine, November, 1861.

At the last ordinary monthly meeting of the executive committee of this association, held on Tuesday, October 29th, 1861, Mr. L. E. Fletcher, chief engineer, presented his monthly report, from which we have been furnished with the following extracts:—

During the past month, 438 engines have been examined, and 595 boilers; 22 of the latter being examined specially, 14 internally, 43 thoroughly, and 516 externally. The following defects have been found:—Fracture, 8 (2 dangerous); corrosion, 36 (7 dangerous); safety-valves out of order, 9; water-gauges ditto, 14; pressure-gauges ditto, 8; blow-off cocks ditto, 54 (1 dangerous); furnaces out of shape, 2; deficiency of water, 2; over pressure, 14—total, 147 (10 dangerous); boilers without glass water-gauges, 13; ditto without pressure-gauges, 10; ditto without blow-off cocks, 59; ditto without feed back press valves, 93. In my last report, I called attention to the application of steam jackets to cylinders, pointing out their importance as an agent "for effecting economy in the use of steam."

I now wish to allude to a kindred and equally important subject—viz: that of *Superheating*, the economy derived from which has now become established by general experience, and in marine engines has, in many cases, effected as high a saving as 30 per cent. I scarcely anticipate such a result as this from its application to Lancashire mill engines; still I am confident that a very considerable saving would be effected, while, at the same time, the vacuum would be improved, the temperature in the hot-wells reduced, and less injection water required, which, to steam users having cooling ponds of limited area, would be most important. These results are mainly due to the prevention of condensation and re-evaporation on the internal surface of the cylinder, as explained in my last report relative to the action of the steam jacket; so that the effect of superheating the steam, or coating the cylinder with a steam jacket, is very similar. The application of the jacket, however, to cylinders, can only be made at the time of construction, except with considerable difficulty, while the principle of superheating can be applied to old engines as an auxiliary without alteration to the existing arrangements.

The subject of superheating has been sadly bugbeared. It has been reported that the use of superheated steam would destroy the surface

of the cylinder, piston, and slides, by preventing lubrication; also, that it would corrode the metal; that it was highly explosive, productive of great pressure, and altogether dangerous and difficult to deal with. Actual experience, however, has proved that these objections are entirely visionary, and I have only within the last few days been assured by the superintending engineer of all the engines and boilers in the large fleet of the Peninsular and Oriental Steam Navigation Company, where superheated steam is now and has, for some time past, been extensively employed, that no difficulty is experienced in its use, and no alteration whatever is required in the old engines, beyond the introduction of a slightly better description of packing for the glands, while not a trace of corrosion has been found. It only now remains, therefore, for the manufacturing engineers of this district to bring out a simple and efficient superheating apparatus, adapted to mill engine boilers, by which they will not only benefit themselves, but at the same time render essential service to the steam users of the district. I am glad to say that one of our members is now laying down a superheating apparatus, and, as soon as I have an opportunity of doing so, I shall be happy to state to the members of the association the results of its actual working as applied to the boilers of an ordinary mill engine, and to assist in the general introduction of this system amongst all our members by affording any other information I am able. I would state, however, in the meantime, that it is found most advantageous to superheat the steam to about 100 degrees above the temperature of plain steam, when no difficulty is found in lubricating; also, that the utmost care must be taken in maintaining the temperature of the steam when once it has been superheated, or the virtue will be lost before it gets to the engine. I found in one case, that although the temperature immediately on leaving the superheater was as high as 600 degrees, yet it had fallen nearly to 300 degrees on its arrival at the engine. I understand that some parties entertain the idea that superheating may be advantageously applied where steam is used for heating purposes. I am convinced, however, that such would not be the case, and that disappointment will inevitably ensue wherever superheating is adopted with this view.—*Assoc. Prev. Stm. Boiler Explosions.*

Water Gauge.

The Committee on Mechanics of the "*Société Industrielle*" of Mulhouse (France), report favorably upon a new form of water gauge submitted to them by MM. Varillat and Langlois. This consists of an iron tube passing horizontally through the front of the boiler to which it is firmly screwed, and terminating externally in an oblong case. Through the interior of this tube passes an iron rod, supported at its inner end on a socket, and at its outer extremity passing through a stuffing-box into the case before spoken of. The inner end of this rod is attached to a hollow float by means of an arm, so that the ris-

ing or falling of the water will cause the rod to rotate on its axis. The outer end also carries an arm, which is connected by means of a slot and pin with an index which moves on an upright guide in the box, and marks the height of the water on a graduated scale.

This apparatus is no improvement so far as we can see upon the old and simple float-indicator invented by Watt, and reproduces the stuffing-box which the gauges of Faber and Grimes were devised to get rid of. As French machinists have borrowed Faber's magnetic gauge (without acknowledgment, of course,) just sufficiently altered in form to render it difficult to recognise at first sight, they had better stick to a good thing, although badly obtained.

Remarks on Radiation and Absorption. By JOHN TYNDALL.

From the Lond. Mechanics' Mag., November, 1861.

TO SIR JOHN F. W. HERSCHEL, Bart., &c.

DEAR SIR JOHN:—I am anxious to address this note to you upon a subject which you have in great part made your own, because I fear that neither in my book upon the Alps, nor in my recently published papers, have I made due reference to your estimable researches on Solar Radiation. I have been for some time experimenting on the permeability of our atmosphere to radiant heat, and have arrived at the conclusion that true air, that is to say, the mixture of oxygen and nitrogen which forms the body of our atmosphere, is, as regards the transmission of radiant heat, a practical vacuum. The results from which the opacity of air has been inferred, are all to be ascribed to the extraneous matters diffused in the atmosphere, and mainly to the aqueous vapor. The negative results recently obtained by that eminent experimenter, Professor Magnus, of Berlin, have induced me to re-investigate this point; and the experiments which I have made, not only establish the action of aqueous vapor, but prove this action to be comparatively enormous. Here is a typical case:—On the 10th of this month, I found the absorptive action of the common air of our laboratory to be made up of three components, the first of which, due to the pure air, was represented in magnitude by the number 1; the second, due to the transparent aqueous vapor, was represented by the number 40; while the third, due to the effluvia of the locality and the carbonic acid of the air, was represented by the number 27. The total action of its foreign constituents on the day in question, was certainly sixty-seven times that of the atmosphere itself; while the aqueous vapor alone exerted an action at least forty times that of the air.

I have also to communicate to you some results of lunar radiation which connect themselves with your speculations. On Friday, the 18th of this month, I made a series of observations on the moon, from the roof of the Royal Institution. From six concurrent experiments, I was compelled to infer that my thermo-electric pile lost more heat when presented to the moon than when turned to any other portion

of the heavens of the same altitude. The effect was equivalent to a radiation of *cold* from our satellite. I was quite unprepared for this result, which, however, you will at once perceive may be an immediate consequence of the moon's *heat*. On the evening in question, a faint halo which surrounded the moon, and which was only visible when sought for, showed that a small quantity of precipitated vapor was afloat in the atmosphere. Such precipitated particles, in virtue of their multitudinous reflections, constitute a powerful screen to intercept the terrestrial rays, and any agency that removes them and establishes the optical continuity of the atmosphere, must assist the transmission of terrestrial heat.* I think it may be affirmed that no sensible quantity of the obscure heat of the moon, which, when she is full, probably constitutes a large proportion of the total heat emitted in the direction of the earth, reaches us. This heat is entirely absorbed in our atmosphere; and on the evening in question, it was in part applied to evaporate the precipitated particles, hence to augment the transparency of the air round the moon, and thus to open a door in that direction for the escape of heat from the face of my pile. The instrument, I may remark, was furnished with a conical reflector, the angular area of which was very many times that of the moon itself.

October 21, 1861.

*I was going to add " into space," but the expression might lead to misapprehension. My experiments indicate that the absorption of water is a *molecular* phenomenon. If we suppose the aqueous vapor of the atmosphere to be condensed to a liquid shell enveloping the earth, the experiments of Melloni would lead us to conclude that such a shell would completely intercept the obscure terrestrial rays. And if the vapor be equally energetic, our atmosphere would prevent the *direct* transmission of the obscure heat of the earth into space. On this point, however, I wish to make some further observations.

New Tracing Paper.

It is recommended to moisten a sheet of common paper with benzine by means of a sponge. The paper becomes temporarily transparent, and any lines may be traced through it. In a few hours, the benzine evaporates, and the paper becomes opaque as before.

Cosmos.

On the Surface Condensation of Steam. By J. P. Joule, LL.D., F.R.S.

From the Lond. Mechanics' Magazine, November, 1861.

In the author's experiments, steam was passed into a tube, to the outside of which a stream of water was applied, by passing it along the concentric space between the steam-tube and a wider tube in which the steam-tube was placed. The steam-tube was connected at its lower end with a receiver to hold the condensed water. A mercury gauge indicated the pressure within the apparatus. The principal object of the author was to ascertain the conductivity of the tube under varied circumstances, by applying the formula suggested by Professor Thomson,

$$c = \frac{w}{a} \log \frac{V}{v}$$

where a is the area of the tube in square feet, w the quantity of water in pounds transmitted per hour, V and v the differences of temperature between the inside of the steam-tube, and the refrigerating water at its entrance and at its exit.

The following are some of the author's most important conclusions.

1. The pressure in the vacuous space is sensibly the same in all parts.

2. It is a matter of indifference in which direction the refrigerating water flows in reference to the direction of the steam and condensed water.

3. The temperature of the vacuous space is sensibly equal in all its parts.

4. The resistance to conductivity must be attributed almost entirely to the film of water in immediate contact with the inside and outside surfaces of the tube, and is little influenced by the kind of metal of which the tube is composed, or by its thickness up to the limits of that of ordinary tubes.

5. The conductivity increases up to a limit as the rapidity of the stream of water is augmented.

6. By the use of a spiral of wire to give a rotary motion of the water in the concentric space, the conductivity is increased for the same head of water.

The author, in conclusion, gives an account of experiments with atmospheric air as the refrigerating agent; the conductivity is very small in this case, and will probably prevent air being employed for the condensation of steam, except in very peculiar circumstances.

Proc. Roy. Soc.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, January 16, 1862.

M. W. Baldwin, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from Colonel S. H. Long, Bureau of Topographical Engineers, War Department.

Donations to the Library were received from the Royal Society, the Royal Geographical Society, the Royal Astronomical Society, and the Institute of Actuaries, London; the Bureau Topographical Engineers, War Department, Washington, D. C.; John Wiley, Esq., and Jordan L. Mott, Esq., City of New York; the Mechanics Association of Worcester County, Mass.; George R. Smith, Esq., Senate of Pennsylvania, and the Pennsylvania Legislature, Harrisburg; Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of December, and his annual statement for 1861.

The annual report of the Committee on Publications, of the state of the Journal for 1861, was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (10) were proposed, and the candidates proposed at the last meeting (9) were duly elected.

The Tellers of the Annual Election for Officers, Managers, and Auditors for the ensuing year, reported the result, when the President declared the following gentlemen duly elected:—

John C. Cresson, President.

John Agnew,
Matthias W. Baldwin, } Vice Presidents.

Isaac B. Garrigues, Recording Secretary.

Frederick Fraley, Corresponding Secretary.

John F. Frazer, Treasurer.

MANAGERS.

Samuel V. Merrick,	Thomas J. Weygandt,	John E. Wootten,
Thomas Fletcher,	George Erety,	Joseph Hutchinson,
Edwin Greble	Evans Rogers,	William A. Drown,
Thomas S. Stewart,	Robert Cornelius,	Ferdinand J. Dreer,
Alan Wood,	James H. Bryson,	B. Franklin Palmer,
John E. Addicks,	John M. Gries,	Coleman Sellers,
Isaac S. Williams,	Washington Jones,	William Weightman,
George W. Conarroe.	William Harris,	James S. Whitney.

AUDITORS.

Samuel Mason, James H. Cresson,
William Biddle.

At a meeting of the Board of Managers, held January 22d, 1862, the following officers were elected for the ensuing year:

Washington Jones, Chairman.

Isaac S. Williams,
William A. Drown, } Curators.

Mr. Howson, of the Committee on Meetings, exhibited an improved Cannon-sight; also, a Telescope for measuring distances, both invented by Mr. Altemus, of this city.

The main advantages of the cannon-sight are its self-adjustability to the surface of the cannon, and the facilities which it affords to the gunner for taking a rapid and accurate aim; the telescope is provided with a glass disc, so graduated by means of a diamond, that the distance of any object, the height of which is known, can be readily ascertained. The lines made by the diamond on the glass disc take the place of the spider's web heretefore used, and cannot be displaced.

Mr. Howson also exhibited a pair of Manacles, patented by A. Rankin, Esq., of this city. The difference between the new manacles and those in common use, was explained by the exhibitor, who showed that the common manacles could be unlocked by striking them in a peculiar manner against any hard substance.

A Pocket-Album for Photographs, the invention of Mr. Altemus, of this city, was exhibited. The leaves holding the photographs are so hinged to each other, and to the binding, that a number of pictures may be shown and compared at the same time.

Mr. Howson also exhibited a Graduated Glass Measure invented by W. Hodgson, Jr., the graduations of which are formed during the operation of moulding.

Also, a Self-priming Pistol, invented by Mr. Butterfield, being a revolver with a self-priming lock. This has been approved of by the military authorities, who have ordered a large number.

Also, Mr. Andrews' Tobacco-pipe. This has two chambers, separated by a grating on which the tobacco rests, the lower chamber serving as a reservoir for the nicotus, the upper chamber being detachable.

Also, a Portable Writing Case invented by Mr. W. T. Fry; this contains a very complete supply of such articles of stationery as may be needed in traveling and is well adapted for army use.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

DECEMBER.—The month of December, 1861, was warmer than usual, the temperature being $4\frac{1}{2}°$ above that of December, 1860, and about $1\frac{3}{4}°$ above the average temperature of the month for eleven years.

The warmest day of the month was the 9th, of which the mean temperature was 54·2°. The weather from the 4th to the 9th was warm and hazy, resembling the Indian Summer. The highest temperature for the month (64°) occurred on the 10th.

The coldest day was the 28th, with a mean temperature of $26\frac{1}{2}°$. The register thermometer indicated the lowest (19°) on two days, the 4th and the 26th.

The range of temperature for the month was, consequently, 45°.

The temperature was below the freezing point on 21 days of the month, though it rose above that point in the course of the afternoon of every day except the 25th.

No interruption whatever to navigation was caused by ice in either the Delaware or Schuylkill rivers during the month.

The greatest change of temperature in the course of a day was 23° on the 10th; the least was 6° on the 24th. The average daily oscillation of temperature for the month (14·58°) was nearly $2\frac{1}{2}°$ greater than the average for eleven years.

The greatest mean daily range of temperature was 15·7°, and occurred between the 10th and 11th days of the month; the least was 1·3°, between the 6th and 7th. The average daily range for the month (5·66°) was about three-fourths of a degree less than the average for eleven years, and about two-thirds of a degree more than the range for December, 1860.

TABLE I.—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1861.

Latitude, 39° 57½′ N. Longitude, 75° 10½′ W. from Greenwich. Height of Barometer fount, fifty feet above mean tide in the Delaware River.

1861.	Thermometer.									Barometer, reduced to 32° F.								Dew Point.			
			Range.			Means.						Range.		Means.				Means.			
MONTHS.	Maximum.	Minimum.	Monthly.	Mean daily.	Mean daily oscillation.	7 A. M.	2 P. M.	9 P. M.	Average.	Highest.	Lowest.	Monthly.	Mean daily.	7 A. M.	2 P. M.	9 P. M.	Average.	7 A. M.	2 P. M.	9 P. M.	Average.
	°	°	°	°	°	°	°	°	°	Inch.	Inch.	Inch.	Inch	Inch.	Inch.	Inch.	Inch.	°	°	°	°
January,	49½	1	48½	5·98	11·61	27·67	34·34	30·90	30·97	30·526	29·460	1·066	·229	29·991	29·953	29·968	29·971	22·43	25·73	25·59	24·58
February,	68½	—1	69½	8·90	17·27	33·86	45·55	39·14	39·52	30·485	29·308	1·177	·264	29·954	29·912	29·951	29·939	26·56	27·89	29·67	28·04
March,	78½	16	62½	8·66	18·18	37·73	48·71	41·58	42·67	30·386	29·354	1·032	·231	29·917	29·862	29·906	29·895	28·41	28·65	30·58	29·21
April,	88	33	55	5·85	19·05	47·18	60·55	51·10	52·91	30·233	29·213	1·020	·143	29·845	29·787	29·816	29·816	36·44	35·68	39·45	37·19
May,	83	36	47	5·06	19·55	55·40	65·74	57·00	59·38	30·132	29·096	1·036	·156	29·744	29·691	29·726	29·720	42·15	41·78	43·47	42·47
June,	91	51	40	5·29	18·55	69·30	79·27	70·83	73·13	30·062	29·528	·534	·104	29·783	29·742	29·739	29·754	56·69	58·75	60·04	58·49
July,	95	55	40	3·70	19·29	72·74	82·87	72·69	76·10	29·961	29·505	·456	·078	29·800	29·765	29·780	29·781	62·56	60·36	62·62	61·85
August,	94	54½	39½	3·94	16·81	68·88	79·52	71·05	73·15	30·212	29·608	·604	·098	29·912	29·896	29·910	29·906	63·60	63·77	64·20	63·86
September,	86	46	40	4·41	17·22	62·37	74·75	66·72	67·95	30·343	29·283	1·060	·144	29·953	29·913	29·924	29·930	56·94	59·15	59·90	58·66
October,	88	34	54	5·28	16·94	54·32	66·61	58·69	59·87	30·452	29·469	·983	·166	29·945	29·893	29·926	29·921	48·65	51·43	51·07	50·38
November,	63½	29	34½	4·11	13·08	39·85	48·73	43·25	43·91	30·109	29·213	·896	·179	29·793	29·736	29·785	29·771	33·48	33·90	34·04	33·81
December,	64	19	45	5·66	14·58	32·52	42·26	35·88	36·88	30·462	29·292	1·170	·213	30·040	29·992	30·012	30·015	26·90	29·49	29·80	28·73
Annual means,	95	—1	96	5·57	16·85	50·15	60·74	53·24	54·71	30·526	29·096	1·430	·167	29·890	29·845	29·870	29·868	42·07	43·05	44·20	43·11
Winter,	68½	—1	69½	6·63	13·69	30·28	38·51	33·95	34·25	30·526	29·285	1·241	·230	29·961	29·925	29·959	29·949	24·22	26·20	26·42	25·61
Spring,	88	16	72	6·52	18·93	46·77	58·33	49·89	51·66	30·386	29·096	1·290	·177	29·835	29·780	29·816	29·810	35·67	35·37	37·83	36·29
Summer,	95	51	44	4·31	18·23	70·31	80·55	71·52	74·13	30·212	29·505	·707	·093	29·832	29·801	29·810	29·814	60·95	60·96	62·29	61·40
Autumn,	88	29	59	4·60	15·75	52·18	63·36	56·22	57·25	30·452	29·213	1·239	·163	29·897	29·847	29·878	29·874	46·36	48·16	48·34	47·62
Means for 10 years,	100½	—5½	106	5·61	15·19	49·74	60·05	53·20	54·33	30·704	28·884	1·820	·155	29·892	29·853	29·877	29·874		43·67		

Table I (*Continued*).—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1861.

1861. Months.	Relative Humidity. Maximum.	Relative Humidity. Minimum.	Relative Humidity. Range.	Relative Humidity. Means. 7 A. M.	Relative Humidity. Means. 2 P. M.	Relative Humidity. Means. 9 P. M.	Relative Humidity. Means. Average	Force of Vapor. Maximum.	Force of Vapor. Minimum.	Force of Vapor. Range.	Force of Vapor. Means. 7 A. M.	Force of Vapor. Means. 2 P. M.	Force of Vapor. Means. 9 P. M.	Force of Vapor. Means. Average.	Clouds. Sky covered. Means. 7 A. M.	Clouds. Sky covered. Means. 2 P. M.	Clouds. Sky covered. Means. 9 P. M.	Clouds. Sky covered. Means. Aver'g.	Rain, or melted snow. Amount.	Rain, or melted snow. No. of days it fell.	Winds. Monthly resultant.	Winds. No. of times in 1000
	Pr ct.	Pr ct.	Pr ct.	Per ct.	Per ct.	Per ct.	Per ct.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.					Inch.		Direction.	
January,	100	40	60	80 4	71 8	80·7	77·7	·244	·034	·210	·128	·144	·145	·139	·69	·65	·47	·60	4·620	13	N 52° 12′ W	375
February,	100	25	75	75·0	52 5	69·7	65·7	·375	·023	·352	·158	·169	·186	·171	·54	·66	·55	·58	2·124	9	S 77 6 W	351
March,	95	21	74	69 3	47·9	65·7	61·0	·479	·051	·428	·175	·182	·185	·181	·61	·61	·48	·57	3·903	9	N 73 37 W	328
April,	95	22	73	66·9	42·3	65·3	58 2	·520	·109	·411	·231	·226	·259	·238	·50	·61	·47	·53	4·150	9	N 73 30 W	177
May,	100	18	82	62 7	44·5	62·6	56·6	·594	·069	·525	·282	·284	·297	·288	·42	·55	·39	·45	6·240	13	N 72 48 W	257
June,	. 91	19	75	66 2	51·9	69·7	62·6	·813	·142	·671	·475	·512	·530	·505	·61	·61	·39	·54	4·485	15	S 81 52 W	176
July,	97	32	65	71·2	47·7	72·2	63 7	·819	·284	·535	·578	·540	·579	·567	·52	61	·59	·57	2·826	14	S 58 43 W	368
August,	92	31	58	83 4	60 3	79·3	74·3	·811	·296	·545	·602	·608	·612	·607	·70	·64	·50	·61	2 864	12	S 85 55 E	88
September,	97	42	55	82 8	59·8	79·0	73·8	·770	·279	·491	·476	·516	·532	·508	·64	·61	·38	·54	4·976	6	S 75 28 W	181
October,	97	33	64	81·4	59·7	76·5	72 5	·731	·122	·609	·373	·415	·410	·399	·70	·61	·48	·60	3·597	10	N 75 10 W	211
November,	96	32	64	78 2	58·1	70·5	68·9	·523	·099	·424	·199	·210	·206	·205	·52	·67	·52	·57	4·613	11	N 68 12 W	324
December,	95	23	72	79 5	61·9	78 5	73·3	·390	·069	·321	·155	·175	·173	·168	·60	·56	·33	·50	2 016	4	N 74 3 W	383
Annual means,	100	18	82	74 8	54·9	72·5	67·4	·841	·023	·818	·319	·332	·343	·331	·59	·62	·46	·55	46·414	125	N 81 41 W	239
Winter,	100	25	75	78 1	63·4	74·4	72·0	·375	·023	·352	·139	·151	·155	·148	·62	·67	·50	·60	10·045	30	N 65 37 W	354
Spring,	100	18	82	66·3	44·9	64·5	58·6	·594	·051	·493	·229	·231	·247	·236	·51	·59	·44	·51	14·293	31	N 73 18 W	251
Summer,	97	19	78	73·6	53·3	73 7	66·9	·841	·142	·699	·552	·553	·574	·560	·61	·62	·49	·57	10·175	41	S 61 23 W	156
Autumn,	97	32	65	80·8	59·2	75·3	71·8	·770	·099	·671	·349	·380	·383	·371	·62	·63	·46	·57	13·186	27	N 76 25 W	204
Means for 10 years,	100	13	87	76·2	57·6	72·5	68·8	1 059	·013	1·046	·326	·343	·347	·339	·59	·60	·44	·54	44·864	126	N 75° 37′ W	217

TABLE II.—*A Comparison of some of the Meteorological Phenomena of* DECEMBER, 1861, *with those of* DECEMBER, 1860, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Dec. 1861.	Dec. 1860.	Dec. 11 years.
Thermometer.—Highest,	64°	50°	71°
" Lowest,	19	13·5	5
" Daily oscillation,	14·58	12·2	12·23
" Mean daily range,	5·66	5·0	6·36
" Means at 7 A. M.,	32·52	29·32	31·73
" " 2 P. M.,	42·26	35·65	39·21
" " 9 P. M.,	35·88	31·82	34·57
" " for the month,	36·88	32·26	35·17
Barometer.—Highest,	30·462 in.	30·418 in.	30·678 in.
" Lowest,	29·292	29·285	28·946
" Mean daily range,	·213	·196	·212
" Means at 7 A. M.,	30·040	29·937	29·961
" " 2 P. M.,	29·992	29·911	29·923
" " 9 P. M.,	30·012	29·958	29·945
" " for the month,	30·015	29·936	29·943
Force of Vapor.—Means at 7 A. M.,	·155 in.	·132 in.	·142 in.
" " " 2 P. M.,	·175	·140	·169
" " " 9 P. M.,	·173	·134	·155
" " " for the month,	·168	·135	·155
Relative Humidity.—Means at 7 A. M.,	79·5 per ct.	78·9 per ct.	77·3 per ct.
" " " 2 P. M.,	61·9	65·8	66·2
" " " 9 P. M.,	78·5	72·7	75·6
" " " for the month,	73.3	72·5	73·0
Rain and melted snow, amount	2·016 in.	3·301 in.	3·707 in.
No. of days on which rain or snow fell,	4·	8	10·1
Prevailing winds—Times in 1000-ths,	N74°3′W. ·383	N51°45′W ·411	N56°43′W ·291

The pressure of the atmosphere was greatest on the morning of the 13th, when the mercury stood at 30·462 inches; but the average pressure for the day was greatest on the 12th, the mean for that day being 30·413 inches, while for the 13th it was but 30·360 inches. The atmospheric pressure was least on the 23d of the month, falling as low as 29·292 inches, during the prevalence of a heavy continuous rain. The average pressure for the day was 29·411 inches. The monthly range of pressure was 1·170 inches. The average pressure for the month (30·015 inches) was greater than for any December since 1851; it was 0·076 in. greater than in December, 1860, and 0·072 in. above the average for eleven years.

The greatest mean daily range of atmospheric pressure was 0·768 of an inch, between the 22d and 23d days of the month; the least was 0·006 of an inch, between the 9th and 10th; and the average mean daily range for the whole month was 0·213 of an inch, which is almost identical with the average range for the whole period of observation.

The force of vapor and dew-point were greater than usual. The force of vapor was greatest (0·390 in.) on the 9th, and least (0·069 in.) on the 15th of the month. The average for the month was above the general average.

The relative humidity was greatest (95 per cent.) during fogs on

the mornings of three days, viz: the 7th, 18th, and 23d, and least (23 per cent.) on the afternoon of the 15th of the month. The average for the month was very near the general average.

Rain or snow fell on but four days of the month, viz: on the 11th, the 22d, and 23d, and early on the morning of the 27th; the aggregate depth being only 2·016 inches, of which more than three-fourths fell from 9 P. M. on the 22d, to 7 P. M. on the 23d. The number of rainy days was less than ever before observed for the month of December, and the amount of rain and melted snow was less than for any other December since the year 1851, when less than two inches fell. The average number of rainy days for December is 10, and the average amount of rain and melted snow for the month in a period of eleven years is 3·707 inches.

There were but two days of the month, the 5th and the 13th, entirely clear or free from clouds at the hours of observation; and the sky was completely covered with clouds at those hours on but two days, the 1st and 22d of the month. The average amount of the sky covered with clouds during the month of December, 1861, was about 50 per cent.; during December, 1860, it was 60 per cent., and the average amount for eleven years is a little over 58 per cent. of the visible sky.

The Year 1861.—The year 1861 was warmer than usual. It was about six-tenths of a degree warmer than 1860, and nearly four-tenths of a degree warmer than the average temperature for the last ten years.

The maximum temperature (95°) occurred on the 8th of July; the minimum temperature (—1°) one degree below zero, on the 8th of February.

The warmest day of the year was the 8th of July, of which the mean temperature was 87·8°. The coldest day was the 13th of January, the mean for that day being 7·8°.

Of the seasons, the Winter was nearly one degree (·96) warmer, and the Summer more than one and a quarter degrees (1·27) colder than the average for ten years. The Autumn was half a degree warmer than usual, while the Spring was very close to the average temperature for the whole period of observation.

All of the months, with the exception of three, were within two degrees of their average temperature. The greatest variation was in February, which was (5·7°) more than five and a half degrees warmer than usual. It was the warmest February for ten years, with the exception of February, 1857, which was half a degree warmer. The month of October was more than three degrees (3·16°) above the average temperature of that month, and was the warmest October during the whole period of observation. May was about three and a half degrees (3·52°) below its average temperature, and was the coldest May for ten years, with the single exception of May, 1858, which was seven-hundredths of a degree colder. The average temperature of each month is exhibited in Table I.

The maximum pressure of the atmosphere (30·526 in.) occurred on

the 23d of January, and the minimum pressure (29·096 in.) on the 27th of May. The average pressure was a little greater than that for 1860, but it still fell below the average for ten years.

The Delaware river was not closed with ice during the whole year. It has not been closed to navigation since the beginning of March, 1858. The Schuylkill river below Fairmount dam, has not been closed since January, 1860.

The different storms of the year, the beautiful aurora of the 9th of March, and the comet of July, have all been referred to in the reports of the months in which they occurred, already published in the Journal.

Table I. contains a general abstract of the observations made during the year; the barometric observations being corrected for temperature, but not for altitude; the barometer fount being fifty feet above mean tide in the Delaware river.

Table II. contains the usual monthly comparisons for December.

Table III. contains a comparison, in the usual form, of the year 1861, with 1860, and with the average results for ten years.

TABLE III.—*A Comparison of some of the Meteorological Phenomena of the year* 1861, *with those of* 1860, *and of the last* TEN *years, at Philadelphia, Pa.*

	1861.	1860.	Ten Years.
Thermometer.—Highest degree,	*a* 95°	*f* 95·5°	*k* 100·5°
" Mean of warmest day,	*a* 87·8	*f* 87·7	*k* 91·3
" Lowest degree,	*b* —1·0	*g* 1·0	*l* —5·5
" Mean of coldest day,	*c* 7·8	*g* 9·2	*m*—1·0
" Mean daily oscillation,	16·85	17·12	15·19
" " daily range,	5 57	5·65	5·61
" Means at 7 A. M.,	50·15	49·39	49·74
" " 2 P. M.,	60·74	60·35	60·05
" " 9 P. M.,	53·24	52·61	53·20
" " for the Year,	54·71	54·12	54·33
Barometer.—Highest,	*d* 30·526 in.	*h* 30·418 in.	*n* 30 704 in
" Lowest,	*e* 29·096	*i* 29·099	*o* 28·884
" Mean daily range,	·167	·143	·155
" Means at 7 A. M.,	29·890	29·882	29·892
" " 2 P. M.,	29·845	29·833	29·853
" " 9 P. M.,	29 870	29·862	29·877
" " for the Year,	29·868	29 859	29·874
Force of Vapor.—Means at 7 A. M.,	·319 in	·311 in.	·326 in.
" " " 2 P. M.,	·332	·321	·343
" " " 9 P. M.,	·343	·329	·347
" " " for the Year,	·331	·320	·339
Relative Humidity.—Means at 7 A. M.,	75 per ct.	75 per ct.	76 per ct.
" " " 2 P. M.,	55	54	58
" " " 9 P. M.,	72	71	73
" " " for the Year,	67	66	69
Rain and melted snow, amount	46·414 in.	45·400 in.	44·864 in.
No. of days on which rain or snow fell,	125	131	126·
Prevailing winds—Times in 1000-ths,	N81°41′W·239	N79°43′W·219	N75°37′W·217

a July 8. *b* February 8. *c* January 13. *d* January 23. *e* May 27. *f* July 20. *g* February 2. *h* December 14. *i* February 18. *k* July 21, 1854. *l* January 23, 1857. *m* January 9, 1856. *n* January 28, 1853. *o* April 21, 1852.

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OF THE STATE OF PENNSYLVANIA,

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PROMOTION OF THE MECHANIC ARTS.

MARCH, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Description of a Portable Coffer Dam used at Fort Taylor, Key West, 1861, and of a proposed new Tremis. By Captain E. B. HUNT, Corps of Engineers, U. S. A.

IN the *Journal of the Franklin Institute*, December, 1860, is published a discussion of this dam, in anticipation of its use. Having now given it a fair trial, and having found its value very great in the case I have had in hand, a more precise account of its arrangement and working is presented.

Coffer dams are usually *fixed*, and consist of two or more sheathings between which a puddled wall is packed. In Daniel Stevenson's so-called Portable Coffer used in the River Ribble, the dam had to be taken apart and put together again when moved. No case of a really portable coffer has come to my knowledge. The Fort Taylor dam is movable without dismemberment, being dragged endwise from section to section of the wall. It has been used in depths up to six feet, and I have no doubt but it can be worked in very much deeper water.

The novel principle in this dam is in the use of a canvas sheathing of the coffer and of the end adjacent to the bottom edge of the coffer. The pumping of the enclosed space brings the pressure of the water to bear on the canvas, which sucks tight to the coffer and bottom, thus cutting off all flow of water except such as may enter at the outer edge of and flow under the canvas flap spread on the bottom.

The bottom along the line of wall now built, is a compact and some-

what irregular ledge of oölitic island stone, covered with from two feet to an inch of mud, sand, &c. This rock is soft enough to admit the driving in it of iron bars by sledges. After careful consideration, I determined to build the coffer of a series of horizontal wales, separated by blocking permanently sheathed with tongued and grooved inch boards, making a bottomless box with water-tight sides. At one end the timber was carried up solidly, and a set of cross-ties bonded together with the wales, to give a rigid support for the pumping apparatus. The wales and blocking were bored for a set of two-inch round iron bars to be driven into the rock as piles and to receive the side pressures, thus saving all need of cross bracing in this instance. The outer dimensions of the box are 50 by 22 feet, and the included wall is 8 feet thick. Each section is 41 feet long, of concrete entirely, and having a slope of 45 degrees in the upper section of 6 feet high. When no special difficulties are encountered, one of these sections is made in from three to four days, including the moving of coffer and preparation for the next section, or at the best, two sections in a week complete.

The canvas case and flap are simply good No. 2 cotton duck of single thickness. I first had the flap made 20 feet wide, but have reduced this to 10 feet. Along the bottom angle, I have had a second thickness sewed on, one breadth wide, half being on the case and half on the flap. This is the part chiefly subject to wear and strain. In the first section, the case and flap were complete. In the second, one end was split along the middle, and the opening was closed around the end of the first section. A movable bulkhead was made which can be adjusted to the cross-section of the wall. Drag ropes on the outer edge of the flap facilitate its manœuvre in the water, and in greater depths will be the main reliance. It has been necessary to contend with a strong tidal current. A very important point is to have a quantity of sand bags to throw down on the edge of the flap, and along the bottom of the coffer. These bring the canvas to its bearing and can never harm it by irregular strains. They are easily recovered prior to moving, and indeed, each bag may have its own cord with buoyed end, so that they can be used very freely at considerable depths. The case is lightly tacked to the coffer, and eased off from the top when a severe strain by pressure requires. In one instance, inattention to this caution caused the canvas to split and flood the enclosure; such damages are, however, easily repaired by the sail-maker. In fitting the end around the cross profile of the last section, much care is required, the chief leakages having been encountered there. Light india rubber cloth yielding to slight pressures, has served a good purpose here.

The pumping apparatus consists simply of four barrel-pumps worked by the walking beams and driven by a six horse power portable engine, the same which has been used for hoisting on the Fort and made at the Columbian Foundry, N. Y., which supplied the pumps and driving wheels all ready for use. Only the frame had to be made here. This is bolted on the wales and has been moved with the coffer, engine, and all, by simply slinging the pumps. These are furnished with shoes

to rest on the bottom, which lift the pump some six inches to keep it clear of stones, &c. The moving is managed by two shear poles, scarfed together at the top, holding the lifting purchase at one end of a forty-ton scow, the hoisting being done by a crab-purchase on the deck. By thus lifting the pump end of the coffer with all its fixtures, the whole is handled endwise by leading a tackle to an anchor carried out ahead in line. In deep water it moves with great ease. The iron piles are drawn, and the concrete platform struck, at each move. This platform is most conveniently made by carrying a trestle cap parallel to one side, and some 18 feet to 20 feet from it: then using cross stringers and covering plank with close joints in the part where the concrete is mixed. The materials are brought by barrows on runways carried by trestles. I have got up a set of nipping barrows, which are a great convenience and saving, in moving barrels of stone, sand, and cement. They consist simply of the common barrow wheel and two side arms joined at the wheel end by a stiff iron bow spring over the wheel, and banded around the ends of these arms where the wheel pintels pass through them. Two rows of three or four strong sharp teeth take hold of the barrel where these arms are strided over it towards the bottom, it being on end. A thin iron crossbar made to slide in a mortise of one of the arms and fixed in the other, holds the barrel from the wheel. This simple barrow enables men with ease to wheel open barrels to the coffer platform.

The concrete frame within the coffer serves its purpose perfectly well. It consists of two main sills and five profile frames, arranged to hold the plank suspended over the slope. The concrete packed against these gives a good smooth surface. Two of these forms are used, to avoid waiting, while the last section sets. They are first stayed to the coffer, but before moving, weights are put on to prevent floating up, and cleaving from the concrete, which, besides injuring the surface, will open leaks into the new section.

In two sections a very bad bottom was encountered, composed largely of stones, only partly packed in sand. The flap resting on this bed could not of course prevent the water from washing the sand out, and leaving only open stones. A sheathing was here driven down outside the coffer, and thus the coffer was cleared and settled. The flap was rolled up, and the bottom cleared of stones, until the rock was finally reached, when the canvas immediately shaped itself to it and sucked tight. Twelve sections have now been put in, each being entirely founded on the clear rock. In two of these, angles were turned without difficulty.

There is no difficulty in using the purchase on the scow before described for hoisting stones from a wharf, carrying them suspended to the coffer, over the side, lowering in place, and bedding, as perfectly as on dry land. The concrete backing of granite faced walls will thus easily be carried up with the courses, and the whole wall will be quickly built in sections as long as the coffer space.

When much sand is brought up by the pumps, it will be judicious to use spouts for leading the discharged water well away from the flap,

as else it will be found hard to remove the deposited sand. Having thus far had a negro force, which in this mild climate can dive and work in the water for a considerable time without suffering, this precaution has not been required, though I can see its necessity in greater depths and colder waters.

In building concrete walls in the water, this plan offers great advantages over any other. There is a saving of at least 10 per cent. by using the large stone fragments, which can be imbedded as in dry concrete work. There is no loss of cement by passing through water, which will I suppose be from 5 to 10 per cent. in most cases of lowered concrete. The concrete is much better, being well rammed and homogeneous. This is shown by its surfaces, which come out quite sound and smooth, as they never would be in box or tremis work. The facility of execution is quite unequalled. The bottom is perfectly cleared. For granite walls backed with concrete, the economy and advantages are even greater. The headers and streachers can thus be just as well bedded as on dry land. The serious wear and tear of health by diving-bell work is quite avoided, and the water is so easily cleared that operations have all the regularity of dry land masonry labor, night work being wholly avoided.

The experience thus far acquired leads me to regard this canvas or flexible water-proofing as a most valuable extension of building methods. It is indeed a new *principle* of *practice*, which will by ingenious application lend itself to a great variety of cases. It will require judgment to decide whether any particular case favors its use, but with careful study there need be no mistakes. Experience only can limit the depths at which it can be applied. By augmenting strength with pressure, it can go indefinitely deep. Some bottoms would at once prohibit its application. Smooth rock and hard clay will be favorable. I have tried it in sand, and it has succeeded, though much care is required. By using well jointed sheathing, well set up, the plan will work even in soft mud. By giving a slight flare downwards to the coffer, it can be settled within the sheathing. It will not be hard to decide when iron pile supports must give place to or be helped by cross bracing. It is one great advantage of this method of operation, that no great array of preparation is exposed to destruction by storms or accidents. By building the wall thus in solid complete sections, nothing but the dam is exposed. This, as has been shown, will safely bear a considerable sea. A free use of old ship bolts has made the coffer very strong, even though it has some pliability. It was used during the swell of a norther, which would have ruined any coffer depending on puddling. In important works iron sheathing might be preferable, though plank well used are sufficient for most cases. In some instances here, the irregularities of bottom, when using the permanently nailed sheathing, has given gaps of over six inches to be bridged by the canvas, and it has successfully done it. In such cases I have used straw bags, sand bags, and sod scraps to relieve this undue strain, by chinking the holes, before spreading the canvas.

I will suggest an improved tremis, related to this coffer. Instead of

the heavy box spout, through which to pass the concrete under water, I propose a simple canvas spout, made like the trunk of a windsail, and fastened to a top frame ; at the bottom end let a circular or square flap be sewed on. Before immersing, a cord is so tied, at the bottom end, that it can be unknotted by pulling from above. As the trunk goes down, it is collapsed. Begin throwing in concrete at top, until it is sufficiently filled for releasing the bottom stricture ; then unknot the cord, and continue throwing in concrete. It will spread out because of the pressure, under the flap at bottom, filling the space and raising the flap, with almost no water contact. By drag ropes attached to this flap, the bottom of the tremis can be easily lifted as the filling proceeds, and shifted when it is done. We can give to such a tremis any desired strength, by using several thicknesses of canvas. By making the flap a little larger than the section area, the section might be filled without any water contact, the water being simply lifted as the filling proceeds. Certainly the gain in simplicity and economy offered by such a tremis, entitles it to trial, when work of this kind is to be done.

FORT TAYLOR, KEY WEST, Dec. 2, 1861.

Iron-clad Steamers.—Report of the Naval Board on the Stevens Battery.

WASHINGTON, Dec. 31, 1861.

The board of naval and scientific gentlemen appointed by the Secretary of the Navy, agreeably to a resolution of Congress, to examine the Stevens Battery, have, after a long and thorough investigation, reported as follows:—

NAVY YARD, BROOKLYN, Dec. 24, 1861.

SIR—In obedience to orders from the Navy Department, appointing the undersigned members of a board to examine the iron steam battery now building at Hoboken, N. J., and ascertain what will be the cost of completing the same, how soon it can be completed, and the expediency thereof, we met at this place on the 1st ult., and entered upon the above duties by examining so much of the battery as has already been constructed, and by desiring Mr. Stevens to furnish us with plans and descriptions of the vessel as she would be when completed and ready for service.

These latter were received on the 15th inst., previous to which the board had visited the battery frequently; and, having carefully examined the vessel as far as advanced, and the plans submitted for her completion, we beg leave respectfully to

REPORT :—That we found upon the grounds of Mr. Stevens, at Hoboken, situated in an excavation or dock, a long, slender iron vessel, in an unfinished state, evidently intended for high speed in smooth water.

DESCRIPTION OF THE PORTION ALREADY BUILT.

Hull.—The shell of the vessel is completed up to a height of twenty-one feet from the bottom, but without the decks or beams upon which they are to rest. This vessel is 420 feet long by 45 feet extreme breadth. The iron plating, with the exception of a keel plate, which is ten inches wide and one inch thick, and the garboard streaks, which are thirty inches wide and five-eighths of an inch thick, is half-inch thick, riveted to ribs of angle iron six inches deep, three inches wide, and one-half inch thick, a similar angle iron, reversed, being riveted to each rib. These ribs are spaced two feet apart throughout the entire length. Extending across the bottom of the vessel, at each rib, are floor timbers two feet deep, formed of plate iron one-half inch thick, along the lower edge of which is riveted the angle iron ribs, and along the top edge of which is riveted the reversed angle iron.

Boilers.—Upon fore and aft keelsons, of box form, made of plate iron six inches in depth, and fastened to the tops of the floor timbers, are placed two horizontal fire tube boilers, with the tubes over the furnaces. The boilers are arranged similarly to those in our large naval vessels—namely, five on each side with one fire room amidships, running fore and aft, common to both sides. These boilers occupy eighty feet of the length of the vessel, commencing one hundred and twenty-four feet from the stem. Within these boilers are thirty furnaces, with tubes of two and a half inches diameter, and ranging from seven feet to eight and a half in length, placed over them. The shells of the boilers are one-quarter of an inch thick, single riveted, with stays one and a quarter inches diameter, placed twelve inches apart, attached to crow feet, the toes of which are six inches apart, thus staying the flat surfaces every six inches. They contain, in the aggregate, 876 square feet of grate surface, and 28,000 square feet of fire surface as follows:

Tubes,	23,380	sq. feet.
Furnaces,	2,050	"
Connexions,	1,890	"
Tube sheets,	680	"
Total,	28,000	"

Engines.—Immediately abaft the boilers are the main engines, eight in number, already in a nearly completed state, occupying the whole breadth and depth of the present structure for a length of fifty-three feet. There are two propeller shafts, with four engines upon each, so arranged that each propeller is quite independent of the other. The engines are vertical, overhead beam, condensing engines, having common jet condensers, with vertical air pumps, one condenser and air pump serving for two engines. Each cylinder is forty-five and three-fourths inches diameter by three and one-half feet stroke of piston.

The crank shaft of each engine is forged separately, with cranks and crank pins forged on. These shafts are then connected together by a rigid coupling in such a manner that the entire shafting to each propeller during a length of one hundred and eighty-six feet is rigid throughout. The brasses to these shafts are hollow, so that water may

circulate through them and keep the journals cool. The engines are provided with the ordinary slide valve without cut-offs, worked by the ordinary Stephenson link to cut off by lap at about half stroke. All the links upon each side are connected to a reversing gear operated by a pair of reversing engines, very conveniently arranged, so that one man may readily manage—slow down, stop, start, or reverse—the four engines attached to each propeller.

Forward of the boilers are two pumping engines and pumps for feeding the boilers, also two engines attached to each extremity of the same shaft, which extends across the ship, and upon which there is to be a large fan blower, drawing its supply of air down through bomb-proof gratings in the bomb-proof deck above, creating throughout the lower part of the vessel an excess of pressure. This is to cause in the furnaces of the boilers a powerful draft, independent of the height of the chimney, and throughout other parts a thorough ventilation.

Girders and Engine Frames.—In rear of the boilers, attached to the sides of the ship, are strong plate iron beams, running fore and aft, about fourteen feet up from the bottom. To these are attached five plate iron girder frames, extending across the ship, and placed one immediately forward of the forward boilers, and the other four between each pair of boilers. These fore and aft beams and athwart-ship girder frames are very strong, and well calculated to strengthen that part of the hull, besides being capable of supporting any superincumbent weight that may be brought upon them amidships. The engine frames are eight in number, formed of plate iron, each extending quite across the vessel, and firmly fastened to the sides, near the bottom, and at a height of about fourteen feet above it. These engine frames are also well calculated to support any required superincumbent weight which it may be desirable to place upon them amidships.

WORK REMAINING TO BE DONE.

It now remains to complete a small portion of the plating near the bow and stern; put in the beams and decks; attach a fore and aft keelson to the floor timbers amidships throughout the whole length of the vessel; make the flue connexions and chimney to the boilers; connect the engines, and add a few wanting pieces; put in floor plates to engine and fire rooms; make and attach the propeller shaft bearers to the outside of the vessel; supply the propellers; put in the required bulkheads; apply the armor, and the machinery for loading and working the guns, and to manufacture the guns themselves.

CHANGE OF PLANS.

Before describing the plans proposed for completing the vessel, it is proper to state that the original projector of the vessel was the late Robert L. Stevens, Esq., deceased; and that his brother, Edwin A. Stevens, Esq., who now proposes to complete it, has materially changed the plans from what appears to have been originally intended. Instead of the vertical sides above water, clothed with armor and pierced with gun ports, which seems to have been the design of Robert L. Stevens, the plans presented to us bear date of November, 1861, and resemble the inclined armor plated ships, the designs of which

have been patented in England by Captain Adderly Sleigh, in July, 1858, and by Mr. Josiah Jones, in November, 1859, with the important exception that in the English plans the inclined armor is pierced with gun ports, having an ordinary battery, with the guns and gunners protected overhead by a bomb-proof deck; whereas Mr. Stevens places his guns on the top of the upper deck, depending upon their immense size for their own protection, and for the protection of the gunners who aim and fire them, the training and loading of the guns to be accomplished by novel arrangements of steam machinery below the deck, yet to be elaborated; the guns to be trained to a certain position and depressed twenty degrees, to bring the bore in the same straight line with that of a steam cylinder below, to the piston head of which is attached a rammer and sponge.

DESCRIPTION AND PLANS PROPOSED FOR HER COMPLETION.

The present plans of Mr. Stevens for completing the battery, of which the following description is derived from information, with illustrative drawings, furnished upon call of the Board by him, contemplate an ordinary deck forward and abaft the machinery, fourteen feet from the bottom, beneath which will be coal, fresh and salt water tanks, and powder magazines, and upon which will be salt water tanks, provisions and shell rooms. At twenty-one feet from the bottom, a deck, which forward and abaft the machinery will be bomb-proof, by having a bottom layer of plate iron one-half inch thick; above this a layer of wooden planking six inches thick, covered with another layer of iron one inch thick. This deck is continued over the machinery, but in this part is of ordinary material and strength.

The Armor above water.—Over this latter part of the twenty-one feet deck is constructed the inclined armor, extending from three feet beyond the present side of the vessel to fourteen feet inboard, and seven feet high, giving an upper deck, upon which the guns are to be placed, of twenty-three feet wide amidships. This inclined armor is formed of plate iron in seven laminæ, six of which are one inch thick each, and the seventh three-quarters of an inch, making the thickness of iron six and three-quarter inches. Supporting this iron armor are iron beams eight inches deep, filled in between with locust. Under these again are locust planks six inches thick, making in all six and three-quarter inches of iron and fourteen inches of wood, placed at an angle of about twenty-seven degrees with the horizon. The forward and after ends of what may be termed the loading house, within this inclined armor, are inclosed by similar armor, inclined in a fore and aft direction; and it is forward and abaft of this that the twenty-one feet deck is bomb-proof.

The flat deck uniting the upper edges of this inclined armor is one hundred and twenty feet long, and is made bomb-proof by having, first, a layer of plate iron one-half inch thick beneath the beams, between which is laid wooden planking six inches thick, which again receives two layers of iron of three-quarters of an inch thickness each. Through this deck the heated gases from the boilers rise between the bars of a bomb-proof grating, an ordinary smoke pipe rising above the

grating, which is to be removed, if desired, on going into action. Forward of the inclined armor upon the twenty-one feet bomb-proof deck are the capstan for weighing the anchors and the quarters for the men. Abaft the armor, upon the same deck, are the quarters for the officers, cabin, ward room and steerages. This bomb-proof deck and the inclined sides of the armor are covered with a light deck of two inch planking, supported by wooden beams five inches square and two feet apart, placed at such a height that its upper side is flush with the bomb-proof platform upon which the guns rest. The edges of this light deck are supported by light iron sides one-quarter of an inch thick, running up vertically from the outboard edge of the armor.

The Armor below water.—From the twenty-one feet line downwards six feet, the sides of the vessel are protected by armor composed, first of oak timbers placed next to the iron plating of the ship, having a thickness at its upper edge of three feet, with a triangular cross-section, such that its outboard side forms a continuation of the slanting side of the vessel, which, up to this point of meeting the armor, has an angle with the perpendicular of about twenty-six degrees. From the twenty-one feet line down to the outer side of this oaken armor extends to a depth of three feet, iron plating two inches thick, within which, down to a depth of two feet, is iron plating one and one-half inches thick, so that the side armor of the vessel, extending throughout its entire length, consists of iron three and a half inches thick to a depth of two feet, and two inches thick for one foot further down, backed by solid oak three feet thick at the upper edge amidships, the thickness gradually lessening as it descends, until at six feet depth the iron sides of the vessel itself are depended upon. As the vessel will draw twenty-one feet when loaded with stores, ammunition, and coal, the upper edge of this side armor will be on a level with the surface of the water. Near the bow and stern the oaken part of the side armor is not so thick as amidships, being two feet thick at its upper edge at forty feet from the bow and sixty feet from the stern.

Masts.—There are to be two short masts of hollow plated iron, arranged with hinges near the deck, similar to those in the English steamer *Great Western*, so that they may be lowered to the deck when going into action.

The Armament.—The armament proposed consists of five 15-inch Rodman guns, weighing with their carriages 60,000 pounds each, and two 10-inch rifled guns, weighing with their carriages 40,000 pounds each. These, as before stated, are placed upon the extreme upper deck, over the engines and boilers. The deck upon which they rest is supported by columns of wrought iron, which rest upon the engine frames and the strong plate iron girders before described as rising from the bottom and sides of the ship between the boilers. These guns are mounted upon carriages of a novel construction, so arranged that they may be trained to any point in the horizon by simply revolving a vertical shaft, which passes down through the deck and is attached to steam machinery below. The upper end of the shaft terminates in a T head or horizontal cross bar, whose length is equal to the interior

breadth of the gun carriages. Between this head, or cross bar, and the interior ends of the carriage are india rubber springs forty inches long, and when the gun is fired it is expected, from experiments which have been tried with a ten-inch gun of 10,000 pounds weight, and a charge of powder of eighteen and three-quarters pounds, throwing solid shot weighing 124 pounds, and calculations deduced from them, that the gun will recoil at a maximum twenty inches, or one-half the length of the springs, and that the reaction of these springs will restore the gun to the position which it occupied before it was fired—similar springs upon the opposite side of the cross bar receiving the shock caused by their reaction.

It is expected there will be one man on this upper deck in time of action to each gun, who will direct by appropriate signals, or indicators, its training to those below, and aim and fire it. It is considered by Mr. Stevens that guns of this size will not be injured even when struck by the enemy's shot. This, however, is to be the subject of experiment before the completion of the vessel, and if an opposite result should be arrived at from these trials, they are to be protected by wrought iron armor, in a manner about which he has no doubt, and that when a gunner sees a shot coming he can stand on the friendly side of the gun for protection, the carriage underneath the gun being made shot-proof by wrought iron armor plates. When the gun is to be loaded, the gunner on deck causes it to be trained to the loading position, which in each case brings the gun nearly in line with the keel; he then depresses it about twenty degrees, bringing its muzzle opposite a bomb-proof opening in the deck corresponding in size and direction to the bore of the gun. Below the deck is a long slender steam cylinder, having upon the outer and upper extremity of its piston rod a compound sponge and rammer. The attendant admits steam to either side of this piston as required and sponges out the gun; then the ammunition, being placed in a position near the muzzle, is rammed home by the steam rammer, after which it is elevated by the gunner above, trained upon the enemy and fired.

PROTECTION BY PARTIAL SINKING.

When the vessel prepares for action with the enemy, she is settled to a greater than ordinary draft by the admission of salt water, as follows:

"Water to be admitted into tanks below two feet line,	213 tons.
" " interstices of the coal, .	350 "
Water to be pumped up into tanks on deck, . .	537 "
Total water for settling, ...	1100 tons."

Only one-half of this water is required when the ship is already down to her deep load line, but the whole amount is provided for, so that she may be brought to the fighting draft when her coal and provisions are nearly out. This settling of the vessel is for the purpose of adding to the armor plates the protection secured by water against shot.

TO BE LIGHTED WITH GAS.

The vessel is to be lighted with gas generated on board by placing the retort in one of the boiler furnaces, in a manner similar to that now in use on board the ferry boat *Hoboken*.

FLOATATION AND STABILITY.

To determine the floatation and stability of the ship, we have carefully computed the weight of the vessel and all that it is expected to put in it, with their centre of gravity, the displacement of the vessel, the centre of gravity of displacement, and the height of the metacentre. The displacement of the side armor is included in computing that of the vessel, and the extra beam it gives the ship was considered in estimating the height of the metacentre. The weights include those of four hundred men and officers, provisions for three months, ten thousand gallons of fresh water in tanks, one hundred and twenty-five rounds of shot and shell, one hundred and fifty rounds of powder, and eight hundred tons of coal. The result of the calculation is as follows:—

DRAFT OF WATER, TWENTY-ONE FEET.

Displacement in cubic feet,		188,248
Displacement in tons of 35 cubic fect each,	tons 5,378·5	
Add for iron plating,	18·5	
Total displacement,		5,397·0
Area of midship sections,	sq. ft.	817·0
Arch of load water line,		13,788 0
Displacement per inch at load line,	tons 32·8	
Weight of loaded ship by computation,	5,280·0	
Add for contingent,	117·0	
Total weight provided for,		3,397·0
Depth of centre of gravity of loaded ship, below load water line,		ft. 5·49
" " " displacement, " " "		8·657
Height of metacentre above centre of gravity of displacement,		10·535

Data for Judging of the Form of the Vessel.

Midship Section.		Areas of Immersion Section.	
Height from bottom.	Breadth.	Distances from bow.	Areas.
Feet.	Feet.	Feet.	Square feet.
21	51·0	20	51·0
20	49·8	40	136·8
19	48·8	60	240·0
18	47·8	80	250·6
17	46·8	100	466·0
16	45·8	120	584·6
15	44·8	140	783·0
14	43·8	160	748·8
13	42·8	180	799·8
12	41·8	200	817·6
11	40·8	220	803·4
10	39·8	240	776·4
9	38·8	260	704·0
8	37·8	280	617·8
7	36·8	300	516·4
6	35·8	320	422·4
5	35·0	340	323·2
4	33·8	360	228·2
3	32·2	380	120·6
2	28·0	400	33·8
1	17·6	——	——

Having thus described the vessel and its appurtenances, it remains to state the cost, time required for its completion, and the expediency thereof.

COST.

The total cost of the vessel complete (except stores) is estimated to be, ...	$ 1,283,294·00
Of this amount there has already been paid by the government,	500,000·00
Leaving yet to be provided for, . . .	783,294·00
Of this latter sum Mr. Stevens states that he has expended from his own resources towards the completion of the ship,	228,435·87
Leaving as a representative of the amount of work yet to be done, ...	554,858·13

TIME REQUIRED FOR COMPLETION.

The time required for completing the entire structure, ready for service, is estimated by Mr. Stevens at four months from the date of recommencing the work.

EXPEDIENCY OF COMPLETING HER.

The expediency of incurring the above expense in producing such a vessel as described, is best determined by examining in detail the many novel characteristics she would possess.

She differs from the ordinary war vessels with which we are acquainted. First, in having long slender ends. Second, in employing two independent propellers with several engines attached to each. Third, in depending entirely upon a fan blower for the ventilation of the lower part of the vessel when in action. Fourth, in employing a heavier armament than has ever yet been put afloat, and training and loading these heavy guns by steam machinery below the deck, manipulated by persons who do not see the guns. Fifth, in having the guns exposed to the direct fire of the enemy upon the top of, instead of within, an iron-clad vessel. Sixth, in settling the vessel when going into action, and in several other respects which will develop themselves in the course of this report.

1. The great length of this vessel, compared with the transverse strength, strikes a nautical man at once, and a careful investigation clearly indicates that it would be the height of professional imprudence to send such a vessel to sea. The action of the waves would cause her to writhe and twist to an extent that would soon open the seams of her light iron sides. Her use, if completed, would therefore be confined to the defence of the harbor; her inconvenient length and her draft of water, which could not be reduced to much less than nineteen feet, even for this service, when fully equipped, would militate against her usefulness to a certain extent.

2. The employment of two independent propellers instead of one would appear to possess great advantages in effecting great rapidity of manœuvres when in the presence of the enemy, and would be all the more useful to her for being compelled to confine her operations to the defence of the harbor, the channels of which would be comparatively restricted by her great length and draft of water.

The application of more than two engines to one propeller shaft, arranged, as in the case of this vessel, to occupy a considerable por-

tion of its length, has its advantages and disadvantages. It no doubt distributes over a greater area the reactive strains which the engines bring upon the vessel when they are in operation, but it also adds to the first cost of the machinery, the space occupied, and the labor of attendance.

3. In ventilating the lower part of the vessel by artificial means during action, it must not be forgotten that fresh air is a constant necessity to human life, and to maintain it in this vessel there must be always steam up and the fan in operation.

4. One of the most important features of the vessel is that of using very heavy guns. The five 15-inch smooth bore and the two 10-inch rifle guns throw fifty per cent. greater weight of metal, per broadside, than our heaviest forty-four gun steam frigates, armed with heavy Dahlgren guns.

5. It being a part of the design of this vessel that these guns shall be large enough for their own protection against the shot of the enemy, it would be well to examine the question of how large must be the mass of cast iron to secure it against injury from such a source. The 15-inch Rodman gun, now at Fortress Monroe, is four feet diameter at the breech, and two feet one inch at the muzzle, is fifteen feet ten inches long, and weighs 49,100 pounds. Experiments were tried at Woolwich, in England, in September, 1857, by firing from a sixty-eight pounder, ninety-five hundred weight gun, with a charge of sixteen pounds of powder, four wrought iron shot, at a distance of six hundred yards, and cast iron shot at a distance of four hundred yards, at a target composed of three cast iron blocks, each eight feet long, two feet high, and two and a half feet thick—average weight of each block eight tons. They were placed one above another, a groove being cast on the upper surface of the upper block, three inches deep by fourteen inches wide, to receive a corresponding projection on the under surface of the block above it. This target was supported in rear by a rectangular mass, consisting of six heavy blocks of granite, each block $4\frac{1}{2} \times 3 \times 2$ feet, leaving four and a half feet of the centre of the target unsupported. This wall of cast iron was struck ten times and entirely destroyed. (*Vide* "Naval Gunnery," by General Sir Howard Douglas, fifth edition, pp. 404 and 405.)

There is no doubt in our minds that the metal of the Rodman gun is much stronger than that of the cast iron blocks forming the target above described—(for reason of which see "Notes on Sea Coast Defence," by Major Barnard, U. S. A., p. 36)—but still the results are so remarkable that until further experiments are tried, bearing more immediately upon the case, we cannot consider any cast iron gun as proof against the assaults of heavy ordnance when exposed, as these are, to the direct aim of the enemy, by being placed upon the extreme upper deck of the vessel, with neither bulwarks nor railing to screen them from view, and with the necessity of being trained to a position nearly in line with the keel every time they are loaded. Mr. Stevens has stated to the board that, if experiment shall establish that the guns

are not thus, in themselves, their own protection from the effect of shot, he is prepared to clothe them with angular wrought iron armor, which he considers will be effective.

6. The project of settling the vessel down two feet beyond her deep load draft, when preparing her for action, by admitting water from the sea to different compartments of the vessel, and, after the battle is over, elevating her again to the normal draft, by pumping the water out, is so remarkable a departure from all previous naval practice, that the board has given the subject considerable attention in its various bearings upon practical operations.

First, with regard to the compartments within the vessels which are to receive this water. The statement of Mr. Stevens upon this point is that 213 tons are to be admitted into tanks below two feet line. Now, these tanks are neither more nor less than the spaces between the floor timbers of the ship, or, in other words, the bilge, a part of the vessel that every prudent commander keeps as free from water as possible; but, aside from this, it is well known that the bilge water, of steamers especially, is constantly liable to choke the pumps, on account of the debris contained in it, so much so that in all good steamships several different pumps are arranged to pump from the bilge, not so much with the expectation that they will all be required at once, as that some of them may certainly be in good pumping order.

The statement of Mr. Stevens further is, that 350 tons are to be put into the interstices of the coal. This we regard as highly impracticable. To say nothing of the impossibility of getting coal from the bunkers while they are full of water, the difficulty of again pumping the water out, filled as it would be with small particles and dust of the coal, entirely precludes, in our opinion, the use of that part of the ship for such a purpose. Mr. Stevens proposes to use a kind of pump for this purpose which, it would appear, has worked very well for similar purposes in civil engineering. Its application to vessels of war, however, is novel, and it is liable therefore to the objection of all untried projects.

Secondly, the quarters for the men and officers are upon the bomb-proof deck, which is about on a level with the surface of the water at the ordinary deep load draft, and would therefore be about two feet below it when the vessel was in action. The sides above this deck are made of thin iron, easily perforated by the lightest artillery, so that a heavy shot forward or abaft the loading house, making a large perforation near the water line, would flood this entire deck, adding immediately an enormous weight to the vessel for which no provision has been made. But one consequence could follow such a disaster—the ship would sink.

From these considerations, it is very clear to us that whatever theoretical excellence there may be in partially sinking the vessel for her better protection in time of action with an enemy, the plans here proposed for putting the project into execution are entirely impracticable, and would never be resorted to by any prudent commander.

HULL NOT SUFFICIENTLY STRONG TO SUPPORT THE ARMOR.

The sides of the vessel above the fourteen feet line have no extra support beyond those usually applied to a merchant steamer; and yet in the proposed plan they are to sustain the weight of the side armor and the upright side, which rises from its outer edge, which amount to 350 tons; added to this is one-half the upper inclined armor, which protects the sides of the loading house under the guns, making together 800 tons to be carried by the upper edges of these light overhanging sides, without any extra provisions being made to carry any extra weight whatever. This strikes us as a remarkable defect, which it would be difficult to remedy in any manner, even if the buoyancy was sufficient to carry the added weight of such remedies.

EFFICIENCY OF THE ARMOR.

Aside from the above defect, there can be little doubt but that the loading house is efficiently protected against the heaviest ordnance now afloat in any part of the world. Above water, the armor is fifty per cent. thicker than that which is applied to the French and English iron-clad vessels, and instead of being placed at right angles to the line of direct fire, is at an acute angle with it—an immense advantage in attaining impregnability.

The side armor, where it joins this upper loading house portion, is well calculated to protect the vessel, if she be kept at all times down to the loaded draft; but forward of this during a length of 96 feet, and abaft for a length of 136 feet, we regard it as very deficient in having the iron plating placed in an inclined position, while the oaken backing only supports it horizontally. Although the shot comes in a horizontal direction, the pressure upon the plating is at right angles to its surface, and, therefore, partially upward; the result would be, that the iron would give way for want of proper support in the direction where the support was needed. This would not admit the first shot that strikes this armor to the interior of the vessel below the bomb-proof deck, but there would be very little protection against the next shot which struck near the same place.

POWER AND SPEED OF THE VESSEL.

In designing the power of the vessel, and determining the amount of steam power which should be placed in her, great sacrifices have been made to attain the very important desideratum in a war steamer —high speed.

It is claimed by Mr. Stevens that her machinery is capable of exerting a power of 8600 horses, and that this will give her a speed of twenty sea miles per hour—greater, it is believed, than that of any war steamer in the world.

Although, for reasons already stated, the sphere of action of the vessel would necessarily be confined to the defence of the harbor, where great speed for any distance would not be required, but where, nevertheless, a high speed, even for a very short distance, might,

when manœuvring against an enemy, be of immense advantage. Indeed, the great power claimed would be of very great advantage simply when applied to the propellers in opposite directions for the purpose of turning around quickly.

To obtain this power of 8600 horses, it is proposed to carry within the boilers a pressure of fifty pounds per square inch, and to run the engines seventy-five revolutions per minute.

With the above pressure and revolutions given, the power would be obtained; but prudent engineers would not place the limit of maximum pressure to be at any time carried upon boilers of this description at higher than twenty-five pounds per square inch. Not the slightest objection is urged against the use of steam of as high a pressure as fifty pounds per square inch, however, even when, as in this case, salt water is to be used in the boilers, because, as far as the latter condition could be brought as an objection, it is replied that such a pressure and the resulting power would only be required for a short time at probably great intervals; but if high pressure is desired, boilers strong enough to carry it with perfect safety should always be provided.

With regard to running these engines at a speed of seventy-five revolutions per minute, it will be remembered that each system of crank-shafts has eight bearings, or one at each engine frame, and that, although the part which receives the power of each engine has been forged separately from the others, they are coupled rigidly together, giving what is virtually a single rigid crank-shaft of fifty-three feet in length, with eight bearings. Each of these bearings are so arranged that it may be turned as on a pivot, both in a horizontal and a vertical direction, which would be a very useful quality if there were but two bearings, as then the axis of each could always point towards the other, no matter in what direction the cramping of the ship would move them. But it is clear that where there are more than two, each bearing must remain in a fixed position, or their axis will not be in a straight line. But these bearings, extended over so great a length of the vessel, would, when the full power of the engines were upon them, depart materially from the straight line which perhaps existed when in a state of rest, and the result would be that the journals of the shafts would be cramped in their bearings to an extent that would cause them to heat beyond the power of water to keep them cool, when running at a higher speed than forty revolutions per minute.

There would be little or no difficulty, however, in overcoming this defect by substituting movable for the rigid couplings between the crank-shafts of each separate engine. With this modification there would be no difficulty, as far as the machinery was concerned, in running them eighty revolutions per minute. The power of 8600 horses would, therefore, be modified as follows:—

The mean effective pressure per square inch upon the piston, when carrying fifty pounds of steam in the boilers, was fifty pounds, in the calculations of Mr. Stevens. When carrying twenty-five pounds in

the boilers, this would be twenty-nine pounds, which would therefore give $8600 \times \frac{80 \times 29}{75 \times 50} = 5320$ horses power. Even this allowance gives the boilers credit for the excellent performance of producing one horse power for every five and one-fourth square feet of fire surface.

If, therefore, 8600 horses power would produce a speed of twenty miles an hour, that of 5320 horses power would give

$$\sqrt[3]{20^3 \times \frac{5320}{8600}} = 17 \text{ miles, nearly.}$$

With regard to having allowed in this modification of the power an increased number of revolutions with a lessened pressure, it may be proper to state that the propellers have not yet been designed, and it will only be necessary to give a less pitch to them than would have been required with the greater pressure.

INABILITY TO FIRE IN A LINE WITH THE KEEL.

One of the important features claimed for this vessel is, that each of her guns may sweep the horizon without changing the direction of the ship; that she would advance upon the foe with her unrivalled speed, firing her enormous guns in a direct line with her keel as she approached. Similarly, that if chased by a superior force, she could retire rapidly at the same time that nearly her whole armament was sending back its destructive shot and shell.

The armament, considered by itself, is certainly as well arranged for firing several guns in a line with the keel as in any other direction; but it will be remembered that, forward of the guns, forming the quarters for the men, and abaft them, forming quarters for the officers, is a light wooden deck made of two inch planking, supported by wooden beams, five inches square, placed two feet apart. Every artillerist knows what would become of this deck upon firing the first 410 ℔. shell across it a distance of 120 feet. It would be demolished, and so also would the same deck where it extends over the inclined armor, when the guns were fired *en* broadside. But here it would not be of so much importance; the deck and the light sides which support it could be dispensed with, and might well be left out in the construction of the vessel; but the deck forward and abaft are necessities, and would be destroyed by any prudent commander only when driven to the last resort. She would be compelled, therefore, to lay her broadside to the enemy, exposing to his fire the full length of each gun every time it was placed in position for loading.

CONCLUSION.

In conclusion, we beg leave to express our highest appreciation of the objects Mr. Stevens has apparently had in view when planning this vessel—the most powerful battery, the highest speed, and the most thorough protection of any vessel yet produced—and our regret that the plans of the vessel as presented to us would not, in our

opinion, accomplish fully and completely the ends proposed. We look with the deepest interest upon every addition to the efficiency of our navy, of whatever character, and gladly hail every improvement made to any department of it; but at the same time we cannot recommend the expenditure of important sums of money upon projects of more than doubtful success when put into practical execution, and, therefore, we do not deem it expedient to complete this vessel upon the plans proposed.

All of which is submitted by, very respectfully, your obedient servants,

S. H. Stringham, President of the Board.
Wm. Inman, Commodore.
Thos. A. Dornin, Captain U. S. N.
Alban C. Stimers, Chief Engineer U. S. N.

Hon. Gideon Welles, Secretary of the Navy, Washington, D. C.

Attached to the foregoing is the

REPORT OF PROF. HENRY.

I readily concur with the other members of the board of Commissioners in the statement given in the foregoing report, as to the condition of the vessel as it now is, and in reference to the general account of the plan proposed by Mr. Stevens for finishing it, as well as in the statement given as to the amount of money and length of time which would be required to complete the vessel in accordance with the plans proposed. I also highly appreciate the objects intended by Mr. Stevens, and the laudable endeavors which he has exhibited to improve the defences of our harbors. But I cannot, with my present knowledge, concur in the decided opinion expressed by the other members of the board in regard to the expediency of finishing the vessel.

If I rightly understand the design of Mr. Stevens, it is not to confine the operations of the battery to inner harbors, but also to employ it in outer harbors, and especially in the waters immediately beyond, and therefore the important problem to be solved is, whether the vessel can be finished in conformity with the general plan proposed so as to withstand the waves of the sea to which she may thus be subjected. All the material objections which have been brought against the plans of Mr. Stevens are, in my opinion, merged in this one question; and from a due consideration of all the facts which have thus far been presented to me, I am not convinced that it cannot be solved. On the contrary, it appears to me that, although the vessel may not be a convenient or safe ship for long voyages, she might be made of sufficient strength to withstand the exposure to which she would be subjected, and to efficiently perform the service required. If requested to do so, I will furnish the reasons for this opinion at some future time.

Respectfully submitted,

Joseph Henry.

Extract from a Paper on the Concrete used in the late Extension of the London Docks. Read before the Royal Scottish Society of Arts. By George Robertson, C. E., F. R. S. E.

From the Lond. Civ. Eng. and Arch. Journal, January, 1862.

The gravel found on the works was not always so free from clay as could be wished. It had often to be screened, to reduce the quantity of sand to the proportions necessary to form a good mortar with the lime used. Concrete is really minute rubble work of pebbles set in mortar, more or less perfect according to the care taken in mixing the ingredients. In theoretically perfect concrete, the mortar should be made, *first*, to insure a perfect matrix for the pebbles to be embedded in; but this is not the usual practice in this country. The great mass of the concrete was composed of one measure of lias lime to six measures of gravel, both being measured by boxes, and not by guess-work. Sometimes, however, a layer of gravel was spread out a foot thick, and then lime laid over it for a depth of two inches. This is not so good a way of measuring as by boxes, because the lime falls between the pebbles, and the concrete is richer in lime than the engineer intends, which is no advantage to the work, and is, of course, a loss to the contractor. When the ballast was moderately dry, 12 cubic yards of gravel and 2 cubic yards of lime made 11 cubic yards of concrete, mixed and deposited. The shrinkage of the dry materials was then 22 per cent.; but if the ballast happened to be very dry, the shrinkage was more, and the same quantities made only 10 cubic yards.

A cubic yard of concrete requires about 38 gallons of water to bring the dry materials to the requisite state of fluidity. Of this quantity nearly 8 gallons enter into chemical combination with the oxide of calcium in the lias, and 30 gallons are either absorbed mechanically by the pores of the lime, retained by capillary attraction between the grains of sand, or lost by evaporation. After the concrete has been mixed and deposited, a gradual expansion takes place from the chemical action of the lime slaking; the less of this swelling, however, the better, as it disturbs the setting of the mortar round the pebbles, and causes friability in concrete. Whenever concrete is made with quick-lime (as it usually is) there must be a certain amount of friability from this cause; and, therefore, when it is important to have no swelling, as in blocks of concrete which have to be lifted, recourse must be had to slaked lime, or else to cement, which contracts rather than expands in setting. In the one case the concrete is long in hardening, having more moisture in it than the lime can absorb; and in the use of cement more expense is incurred. Portland cement is, however, not so expensive as might at first appear from the cement being double the price of lime, because the proportion to the ballast may be considerably reduced.

Some experiments on the expansion of concrete proved to me that it varies a little with the season of the year. In hot summer weather the expansion of a cubic foot in twenty-four hours after mixing was as much as $\frac{1}{30}$th of its bulk, usually $\frac{1}{32}$d; but in frosty weather it rarely

exceeded $\frac{1}{48}$th. The force exerted in the expansion was always sufficient to burst the box in which the concrete had been deposited; the amount might even be measured by the distance the nails were drawn out. Whenever the expansion exceeded $\frac{1}{30}$th of the bulk, I considered the concrete too rich in lime, and that there was more than would, when slaked, fill up the interstices of the sand and flints, and coat each grain with a thin pellicle of lime. More than this is not required, for too thick a coating of lime causes weakness, and not strength.

The gravel and lime were mixed together on a platform of planks, and were turned over twice in the dry state, and twice with water gradually added. The concrete was then wheeled in barrows, and shot into the required place from planks a few feet above. The idea that concrete should be thrown in from a great height is erroneous, for it then falls with too great force, and disturbs the setting of the mass below, causing unnecessary friability. This was particularly noticeable in the deep pits for the counterforts of the north wall of the basin, where the concrete had unavoidably to be thrown from a height of 30 feet. The force of the blow set the whole mass in motion for some feet down, even after setting had fairly commenced. Lias concrete sets slowly, and in this case it was impossible to wait long enough for each layer to become perfectly hard before depositing another, as the wall had to be built with the utmost expedition, as will be seen hereafter. Anything gained in density by a fall of more than 6 feet is more than counterbalanced by the disturbances to the mass below. The grand rule in concrete is, not to disturb it after setting has once commenced. Wherever it is necessary to shovel it into corners, or pack it between stones, it should be done at once, and the concrete not touched again. The swelling of the lime during slaking causes enough natural friability, without increasing it by after-disturbance.

By arrangement in the contract with Messrs. W. Cubitt & Co., the contractors for the greater portion of the permanent work, ground lias lime was sold to them for 10*d.* per bushel; and at this price the cost of making a cubic yard of concrete was as follows:—

	s.	*d.*
$3\frac{3}{4}$ bushels of lime, at 10*d.*,	3	$1\frac{1}{2}$
Loading, waste, and bags for ditto,	0	3
Getting gravel,	0	6
Wheeling do. (say 5 runs),	0	4
Screening and selecting ditto,	0	3
Mixing and depositing,	1	1
Platforms,	0	$1\frac{1}{2}$
Total cost per cubic yard equal	5	8

As the quantity of gravel fit for concrete was uncertain before the ground was opened up, for the sake of simplicity the whole excavation had been estimated as barged away; and for each cubic yard of gravel used as concrete, a certain deduction was made in the monthly payments.

The supply of water for mixing the concrete was obtained from pipes laid down to the various parts of the works, either from the street

mains or from the launder of the pumping engine. In mixing large quantities the expense of laying pipes is soon saved.

The Application—Concrete was applied on the works of the London Dock extension in several ways:—1, In foundationss for masonry or brickwork, as a means of spreading the weight over a large surface; 2, As the cheapest method of reaching a good foundation in the clay or gravel, whether for walls or piers of warehouses, &c.; 3, In the dock walls themselves, wherever the concrete would not be exposed to the alternate action of wind and water; 4, As counterforts or buttresses, on which nothing was to be afterwards built, but where weight was wanted.

In all these cases it is to be noticed that it was applied as a mass, in the monolithic form, which is the true use and value of concrete. Whenever it is moulded into separate blocks, to be afterwards set in proximity to each other, concrete becomes an inferior substitute for stone, although often an economical and useful one.

The whole of the side walls of the two locks rested upon a bed of concrete, of a thickness varying very much with the level of the clay, from 3 feet to 6 inches. The invert of the lock chambers was laid on concrete, and the spandrils of the arch filled up with it. The high chimney of the pumping-engine house stood on a square of concrete of considerable thickness, the pumping engine itself resting on beech piling. As this chimney was very close both to the pumping well (18 feet in diameter) and to the excavation for the lower dock, there was some risk of unequal settlement. A plumb-bob was therefore left suspended in the chimney, which at once would give warning of any inclination either way. Some time after the chimney was built the plumb-bob showed that the shaft had inclined several inches towards the excavation. A quantity of limestone was at once stacked round the base of the chimney on the opposite side, which brought the shaft back to the perpendicular.

Concrete was used as the cheapest means of reaching the clay, in the foundations for the lattice swing-bridges over the locks; the bridge pits resting on arches, the piers of which were of concrete up to a certain height. Columns of concrete were built up likewise in the proper places, upon which cranes and capstans might be placed when required. The whole of the walls and iron columns of the new warehouse rested on trenches of concrete about 8 ft. wide, and averaging perhaps 8 ft. in thickness, from the top of the natural gravel to the level of 17 feet below high water. As the concrete here was not to be exposed to the direct action of water, it was made of Dorking or grey stone lime, in the proportion of 1 of ground lime to 8 of ballast. This lime carries more sand than lias; is but feebly hydraulic, and, indeed, not permanently so at all. It is the lime used in London for building purposes, and by some engineers even in dock work when mixed with pozzuolana.

By far the largest quantity of the gravel found in the excavation was used up in the construction of the walls of the basin, in which everything below the level of 17 feet from high water was of concrete,

faced with 2 feet of Kentish rag-stone, to protect the surface from the disintegrating effects of water. At this low level there was no fear of vessels rubbing against the rough faces of the rag-stone. The general type of the basin walls was much the same as that of the West India Junction Dock walls, where Mr. Rendel used concrete of 1 part of Portland cement to 9 parts of gravel.

The concrete portion of the basin walls was 17 ft. 6 ins. broad at the bottom, and 11 ft. 6 ins. at the top, the face being curved at first to a radius of 11 ft., and then carried up with a batter to the bottom of the brickwork, which was perpendicular. Whenever concrete is faced with rag-stone, it should be built with a batter, and the layers slightly inclining away from the face. All danger of the wall bulging out, or of the face-work peeling off, is then avoided. The Kentish rag-stone facing was hammer-dressed on the joints for a specified distance in, and care was taken to have at intervals long wedge-shaped stones, with the broad end inwards, tailing well into the concrete, which was carefully packed between the joints when first deposited. About two feet high of face-work was first set, and then the concrete deposited in two layers of about one foot thick each. The first layer was allowed to harden for at least 24 hours before the second was deposited, and they were always arranged so as to break joint. A layer of concrete does not thoroughly incorporate with a previous one unless the meeting surfaces be kept rough, and free from sand. But, by sweeping off all sand, and, if necessary, picking the face in furrows, and by breaking joint with the layers, all danger is avoided of either a vertical or horizontal run of water through a mass of concrete. The brickwork of the upper half of the wall, with its counterforts, was not laid on landings, as in the lock walls, but was for three feet set in superior mortar, with hoop-iron bond every three or four courses.

Steel-Surfaced Rails.

From the London Mining Journal, No. 1371.

We learn that the use of Mr. Dodd's steel-surfaced rails, to which we have upon several previous occasions referred, is gradually becoming more extended, through the great durability which they are found to possess rendering their application very economic. The mode adopted for steeling the rails is so simple, that there is little addition to the cost, yet so great is the effect produced upon the rail that it will last at least thrice as long as an ordinary rail, and it is estimated that the saving upon each 100 miles laid is equal to nearly £120,000. We have already mentioned several of the principal lines upon which the rails have been tried, and more recently it has been decided to employ them upon several Scotch Railways, and "after great consideration and examination of rails which have undergone Dodd's patent process for steeling the surfaces," Mr. John Fowler has ordered 1200 tons for the Metropolitan Railway. The case-hardening furnace is easily worked, and in three days the surface of the rail for the depth of $\frac{1}{8}$-inch, can be converted into hard and durable steel.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Alloys of Cadmium. By B. Wood, M. D.

(Continued from vol. xli. p. 29.)*

After so long an intermission, due to circumstances which it would not benefit Science to enumerate, we come to speak of some of the combinations of cadmium with the softer or more fusible metals.

To represent their principal qualities to the eye at a glance, and to facilitate description, I have prepared the following tables, in which several well known metals are arranged as standards of comparison. On these points a few remarks may be required by way of explanation.

SCALE OF HARDNESS.

Different methods of determining the hardness of metals have been adopted, none of which appear to be altogether free from objection. The most accurate mode, by means of a graduated punch worked by lever and weight, adopted by Messrs. Calvert and Johnson, is quite tedious, and the machinery too complicated for common use. Ordinarily the main object of examining a metal in respect to this quality is, not so much to determine the hardness of its particles as indicated by the common method of scratching the surface of another with it, or *vice versa*, nor to ascertain its interstitial compactness as by penetrating its substance by means of a pointed instrument under pressure of a given weight, but rather to find out the relative amount of force it, as a mass of a determinate form, will sustain without yielding or giving way, as compared with other metals in like form and condition. That is, we wish to know its state of coherence *as a body*, subjected to the test of pressure, in comparison with similar specimens of other metals, so as to determine our choice for a particular use. A piece of grindstone will *scratch* iron, though iron is much the harder. A substance may be penetrated in the direction of cleavage, or along the plane of crystallization, with ease, when, at other points, it would resist a greater force. The same may be inferred of those metals that are crystalline, or lamellar, in structure.

Nor is it the absolute hardness of a specimen that is the object of practical concern, but simply to know which of any two or more metals, relatively considered, will, in respect to this quality, best answer the end.

The mode adopted for ascertaining the relative hardness of metals represented by the table, is simple and convenient, and affords a good practical test for common use. Specimens of the metals to be examined are cast in the form of triangular bars, measuring at the sides about a quarter of an inch. These being applied edge to edge and placed under pressure in a vice, the relative hardness of any two

* Errata.—Vol. xl. p. 113, four lines from bottom, for "sooner" *read* "later."

Vol. xl. p. 115, seventeen lines from bottom, after "former," a comma in place of the semicolon.

Vol. xli. p. 26, twenty-five lines from bottom, for "as" *read* "contrary to what."

" p. 27, two lines " after "silver" insert "20 gold."

pieces is determined by the relative amount of indentation received by them. If the one be deeply indented or cut, and the other not sensibly or but slightly notched, the former is reckoned at least one degree the harder—and if no impression be made upon it, it may claim a still higher figure in the scale; its precise place being ascertained by further comparison. If both specimens be strongly indented, although differing in degree, and the indentation of the one be no more than half that of the other, they rank in the same class: or if the difference be still greater, the one may take an intermediate place, or be ranked in the class to which it is most nearly allied, with the sign + or — attached, according to circumstances; or it may be designated by the numbers representing both classes. Thus an alloy of one part of tin and nine parts of antimony being deeply indented by the metals in class 5, while it also reacts upon them strongly, would, to be definite, be represented by — 5. An alloy composed of lead and bismuth, each one part, and tin two parts, being nearly midway in hardness between the classes 4 and 5, may be represented by 4—5; or, for greater precision, by the use of a decimal, 4·5. These remarks apply also to the designation of other qualities.

The metals in the scale are so arranged that to this test each will be found to cut or divide the one next above it, and to be divided by that next below, without perceptible reaction in either case.

A mould for forming such bars (which, for the want of a better, could be carved out, with a chisel, from a slab of soapstone,) may be modeled so as to obtain, at the same casting, specimens for determining the qualities of flexibility and malleability, as below indicated.

FLEXIBILITY.

All metals possess some degree of flexibility. A brittle metal admits of considerable flexion when in thin plates, and the amount will depend upon the thickness of the point operated upon. By bending similar bars of different metals, at a constricted point (so as to prevent yielding at other parts), and noting the number of degrees described before breaking, we arrive at an approximation in this particular. The metals represented by the table, flexed at a point one line in thickness, break as follows—reckoning the angle of breakage from that at which the piece cracks or *begins* to separate:—Class 1, at 5° or less; class 2, over 5° and under 20°; class 3, over 20° and under 45°; class 4, over 45° and under 90°; class 5, 90° and upwards. A metal that may be uniformly bent the thickness named to a right angle may be accounted perfectly flexible. Beyond this the method is unsatisfactory, as the more flexible metals break gradually, sometimes thinning down to a mere thread before separating. Nor is it altogether satisfactory in other cases; and to assist our determinations, we have to take into account not only the angle of flexure, but the mode of fracture, or rather the manner of breaking, as the word "fracture" is usually applied to designate the *appearance* of broken surfaces. Some flexible metals after a certain amount of flexion break short, as though rendered brittle by the process, like cadmium; others, as tin, separate by gradual attenuation. Of the more brittle kinds, some at a certain an-

gle break through abruptly; others at the same point merely crack upon the surface of tensure, separating more and more as the strain is continued, and dividing completely only after a wide sweep. In short, some *tear*, some *break*, others *snap*. Again, some alloys will snap under a sudden strain that admit of considerable flexion if the force be gradually applied. A rigid description would express all these conditions, with terms appropriate to each. Moreover, in order to completeness in regard to this quality, independently considered, not only the amount of flexion, but also the force required to produce it, should be measured: but the *hardness* of the metals will afford some criterion in this respect. I have thought it not out of place, or unimportant, to thus indicate what remains to be done.

MALLEABILITY.

The metals are classified in the scale according to the reduction in thickness they will bear under the hammer, without breaking, whether through the centre or at the margin. Specimens, cast in the form of a bullet three lines in diameter, being subjected to this test, and the amount of reduction measured by means of a pair of callipers, it was found that the metals ranked in class 1 break upon being reduced less than one-tenth of this diameter (brittle); class 2 (slightly malleable) admit of being reduced from one to three-tenths (or nearly $\frac{1}{4}$ in bulk); class 3, from three to five-tenths ($\frac{1}{4}$ to $\frac{1}{2}$), being semi-malleable; class 4, from five to seven-tenths ($\frac{1}{2}$ to $\frac{3}{4}$). The metals belonging to this class admit of being hammered down to thin plates, but crack more or less on the margin, and therefore, although "malleable," are not ranked perfectly so. Class 5 includes all those metals that may be beaten down nine-tenths of their thickness without breaking or cracking—the margins remaining entire—and are characterized as perfectly malleable. They may be further classified according to the usual tables.

When at a loss as to the precise place of a metal under examination, the nature of its cleavage or its subsequent "behavior" under the hammer often assists decision; or it is represented by two figures, as in the case of other qualities.

FUSIBILITY.

The scale in the table is arranged to correspond to the actual melting point as indicated by Fahrenheit's thermometer, taking the unit to represent 100°. Class 1 includes those metals which melt at 100° and under 200°; and so of the others. Since the most careful measurements are liable to error by a few degrees, a latitude of ten degrees is allowed, (and it will be seen by reference to the table that the results of different experimenters usually vary still more widely,) so that if a substance melts at 90°, or a little upwards, it is placed in class 1; if at 190°, in class 2, &c.

It may be thought that the *mean* of two whole numbers ought to be adopted, as the unit of measure, in classification; that, for instance, metals melting at 150°, instead of 100°, should be taken as the true type of the class expressed by the unit 1, allowing a range of deviation so as to include 50° on either side. But the scale was arranged with a view to the employment, when desired, of decimals correspond-

ing to the figures which express the absolute melting point. Thus the fusibility of a metal melting at 150° or 175° would, to be definite, be indicated by 1·5 or 1·75: while, if its precise melting point was not determined, although found by comparative tests to fall somewhere between two numbers, we should make use of both to express it; as, 1—2, or 1·5—2, which indeed, in some cases, is about as near as we can approximate the truth by actual measurement.

The table shows both the temperature of liquefaction and that of congelation, as indicated by the mercurial thermometer (Fah.), the first being assumed as the "melting point." It also exhibits in the same view, the results of different experimenters, varying somewhat from mine, but as much among themselves.

For abbreviations, I prefer using the initials of the English names of the metals, instead of the Latin.

Scale of Hardness, Flexibility, and Malleability, with Examples.

Hardness. Class.	Types.	Flexibility.		Malleability.	
1.	Lead.	1.	Bismuth. 1 An. 3 T. 2 An. 1 Cop. 12 T.	1.	*Brittle.* Antimony. Bismuth.
2.	Tin. 1 B. 3 L.	2.	6 B. 74 T.	2.	*Slightly malleable.* 1 An. 3 T. 8 B. 5 L. 3 T. 2 An. 1 Cop. 12 T.
3.	2 L. 1 T. Bismuth.	3.	Zinc. 8 B. 5 L. 3 T. 1 An. 6 T.	3.	*Semi-malleable.* 1 B. 1 L. 2 T. Zinc (cast).
4.	2 T. 1 L.	4.	1 B. 3 L.	4	*Malleable.* 1 An. 6 T.
5.	1 An. 6 T. Cadmium.	5.	1 A. 9 T. Cadmium. Lead. Tin. Alloys of L. and T.	5.	*Perfectly malleable.* 1 B. 3 L. Cadmium. Lead, Tin, &c.
6.	1 An. 3 T. 2 An. 1 Cop. 12 T.				
7.	Zinc.				

Scale of Fusibility, with Examples.

Classes and Divisions.	Metals and Alloys.	Melt. Liqu.	Melt. Cong.	Melting-Point, Fah., according to different Authors.
1. 1·5	1 Cd. 4 B. 2 L. 1 T.	150°	150°	Varying not far from 70° C. (158° F). Silliman's Journal.
1·5	3 Cd. 15 B. 8 L. 4 T.	150°	150°	Soft betw'n 131° & 140°. Near 140°, perfectly fluid. Lipowitz.
1·5–2	1 Cd. 7 B. 6 L.	180°	178°	
2. 2·	8 B. 5 L. 3 T.	200°	198°	202°, Graham, Chem. 200° to 212°, according to others.
3. 3·	1 B. 1 L. 2 T.	310°		
3·5	1 L. 2 T.	338°	336°	About 360°, Graham. 340°, Austen.
4. 4+	Tin.	426°	420°	442°, Crichton and Rudberg (Graham), Brande, and others. 445·6°, Kupffer (Graham). 410°, Artist's Manual. 450°, Webster. 420° and 440°, Appleton's Dict. Mech.
4·5–5	Bismuth.	476°	470°	497°, Crichton (Gr'm). 507°, Rudberg (ib.) 476°, 497°, Brande. 476°, Parkes, Phillips, and others. 480°, Overman.
5. 5·	207 + L. 58 + T. ($Pb_2 Sn$).	Melt?		Congeals 518°, Graham.
6. 6·	Cadmium.	At melting p't of lead.		442°, Stromeyer (Graham and others). 450°, Sanders. 360°, Daniell (New Amer. Cycl.). 550°, Overman.
6·	Lead.	Below a red heat.		612°, Crichton (Graham). 600°, Webster and others. 590°, Morveau (Artist's Manual). 594°, Overman.
7.	Zinc.	Near a dull red heat.		773°, Daniell (Graham), Brande, and Phillips. 680°, Parkes. 666° and 700°, Appleton's Dict. Mech. 700°, Webster. 770°, Overman.
8.	Antimony.	At a fair red heat.		810°, Parkes, Brande, and others. 1000°, Silliman's Chem. 797° (estimated), Graham. 800° and 850°, Phillips. 800°, Webster. 932°, Overman. 842°, New Amer. Cycl.

CADMIUM ALLOYS.—BINARY COMBINATIONS.

Cadmium with Antimony.

The compounds of cadmium and antimony in the proportions of 1 Cd. 2 A., and 4 Cd. 1 A., are hard and very brittle. They melt at a temperature not varying much from that representing the mean melting temperature of the constituents. They do not disclose properties that give promise of usefulness. In physical characters, they agree substantially with the following, a brief description of which will suffice for the class.

27 Cd. 64 A. This alloy has a dark steel-grey color with a leaden hue and a bright metallic lustre. It is hard and extremely brittle; the fracture is crystalline, and presents something of a conchoidal, and more of a plicated appearance. In hardness, to judge by the ordinary method, it would rank with nickel—it scratches zinc, antimony, and copper—but it is fragile under pressure. It is neither flexible nor malleable in the least appreciable degree. Its fusibility is very nearly the same as that of zinc.

Cadmium with Bismuth.

Cadmium alloyed with bismuth is rendered brittle, though the latter be used in very small proportion. There is little difference in this particular whether the bismuth constitutes an equal part or but one-twelfth of a part. These compounds are quite hard and rigid, and they present a very brilliant appearance unless bismuth largely predominates, when they are disposed to tarnish and oxidize.

$\left.\begin{array}{r} \text{1 Cd. 1 B.} \\ \text{55 Cd. 70 B.} \\ \text{1 Cd. 2 B.} \end{array}\right\}$ The alloy produced by combining the metals in any of these proportions is exceedingly handsome and brilliant. It is of a bright greyish-white color, with a faint reddish tint. The free surface (or that part which, in casting, is free from contact with the sides of the ingot-mould) is smooth, beautifully rounded off, and highly polished. In casting, it takes sharp outlines. It breaks with an even and finely crystalline fracture, the crystals showing like fine angular grains. In fusibility, it ranks with the most fusible mixture of bismuth and lead, and of bismuth and tin.

Hardness 5. Flex. 1. Mall. 1. Fusib. 2·5—3 (near 275° F.).

Cadmium with Lead.

These metals form bright handsome alloys, which are harder, and mostly less fusible, than the corresponding compounds of tin and lead. They are perceptibly harder when newly made than after standing awhile (which would appear to be the case with some other alloys). They also part with much of their brilliancy, assuming more of a leaden hue. Contrary to what would be inferred from the behavior of other alloys, they are less fusible when composed of nearly equal proportions of their constituents, than when the lead predominates to the extent of from four to six parts to one, becoming less fusible up to the point at which the proportions are equalized. Passing from this point, on the other side, the fusibility remains nearly identical,

whether the cadmium be in the ratio of two to one of lead, or six to one, being nearly the same as that of bismuth; but the hardness increases with the addition of cadmium. A few examples will suffice:—

1 Cd. 1 L. Color, bright grey. H. 4—5. Fl. 4. M. 5. Fu. 4·5—5 (about 480°).

1 Cd. 4 to 6 L. Color, leaden-grey (at first brilliant). H. 4—5. Fl. 4. M. 5. Fu. 4·5 (near 440°).

6 Cd. 1 L. Color, bright white, with a bluish hue. Retains its lustre. Less flexible than the preceding, though ranking in the same class. H. 5—6. Fl. 4. M. 5. Fu. 4·5—5 (about 470°).

Cadmium with Mercury.

Contrary to what might be inferred from general descriptions and the case of other amalgams,* the compounds of cadmium and mercury are remarkable for their hardness and tenacity.

1 Cd. 1 M. Form a very tough and malleable *alloy* (for it cannot be strictly called an "amalgam") of a bright silver-white color, and that melts between 350° and 400°, a higher temperature than the mean melting-point of its constituents.† It is harder than an alloy of 2 tin and 1 lead, but softer than cadmium. Its fracture is jagged and hackley. H. 4—5. Fl. 5. M. 5. Fu. 3·5—4.

1 Cd. 2 M. Resembles the preceding nearly in color and character, although somewhat less tenacious, and more fusible. It melts below 280°, but does not soften the least in boiling water. Fusibility 2—3; other qualities undetermined, but may be inferred from the other formulæ. (According to Nickelson's Dictionary of Chemistry, by Ure, "100 mercury and 27·78 cadmium, fuses at 167° F.")

28 Cd. 41 M. H. 4. Fl. 5. M. 5. Fu. ?

Cadmium filings mixed into a paste with mercury at ordinary temperature, form an amalgam that solidifies in three or four hours. It cuts with a smooth surface, has much tenacity, and on breaking shows a rough fracture.

Cadmium with Tin.

Cadmium and tin form hard, malleable alloys of a silvery lustre—the color being such as might be expected from the blending of the two—white, without the yellowish tinge of tin, or the violet-blue shade of cadmium, but approximating to either, as the one or the other metal predominates in the alloy. They are flexible, and perfectly malleable, unless the constituents be contaminated with other metals; a very little bismuth renders them brittle.

2 Cd. 1 T. Nearly resembles cadmium in appearance, but is more

*See remarks on the subject, in vol. xl., page 114.

†Two parts of tin and one part of mercury form a compound so frail and brittle as almost to fall to pieces in handling (equal parts being still more frail). It requires a temperature of about 300° or upwards to melt it. An amalgam made of two parts of an alloy composed of 2 tin and 1 lead, and 1 part of mercury, is also very fragile, and does not melt in boiling water (212°), though it softens very slightly in it. These facts seem to require a modification of the inference stated, upon too hasty generalization, in the paper just referred to, that "the fusibility of the compounds of cadmium and mercury is nearly that of the mean of their constituents," and that the same "appears to be the case with other amalgams." It would appear that although mercury combined with cadmium does not act as a fluidifying agent, but actually the reverse, it may act as such, or be perfectly passive, in other combinations—a point of interest worth examining.

silvery. Free surface, clouded or slightly "frosted."* H. 5. Fl. 4. M. 5. Fu. 4.

1 Cd. 1 T. Silver color. H. 5. Fl. 4—5. (?) M. 5. Fu. 3·4.

1 Cd. 2 T. Very brilliant. Free surface highly polished. H. 5. Fl. 5. M. 5. Fu. 3·4.

As the proportion of tin is increased, the alloy becomes softer and less fusible.

Cadmium with Zinc.

4 Cd. 6 Z. Zinc-color. H. 7+ M. 4—5. Fu. 5—6.

TERNARY COMBINATIONS.

Cadmium with Antimony and Tin.

These form very hard alloys.

1 Cd. 1 A. 3 T. A brittle alloy, though quite strong; somewhat harder than zinc. H. 7. Fl. 1. M.—2. Fu. 5.

1 Cd. 2 A. 12 T. H. 6—7. Fl. 2. M. 2—3. Fu. 4·5.

1 Cd. 1 A. 9 T. A very strong alloy, of a compact structure and bright surface. It casts with little perceptible shrinkage, and makes a handsome and perfect die from a sand mould. Free surface, full and even, and exhibiting a finely frosted appearance. H. 6. Fl. 3. M. 3—4. Fu. 4—4·5.

Cadmium with Bismuth and Lead.

These compounds are remarkable for fusibility, as described in a late number of this Journal; they do not require further notice here, except for comparison with the tables.

1 Cd. 2 B. 1 L. H. 4·5. Fl. 2. M. 2. Fu. 2+

1 Cd. 7 B. 6 L. H. 3+ Fl.—3. M. 2+ Fu. 1·8.

1 Cd. 9 B. 8 L. H. 3+ Fl. 3+ M. 2+ Fu. 2.

Cadmium with Bismuth and Tin.

The compounds of these metals are remarkably brittle in any proportions of combination, unless the tin be greatly in excess. Thus, alloys composed of 12 parts cadmium, 1 of bismuth, and from 1 to 24 tin; or 1 cadmium, 1 bismuth, and 1 to 24 tin; or 1 cadmium, 12 bismuth, and 250 or less of tin; are all very brittle, requiring nearly twice as much tin as the largest amount named, in order to render them perfectly malleable. They do not seem to differ materially in hardness whether the tin be used in the smaller or larger proportions mentioned. They approach more or less to a pure silver-white, and are very brilliant.

1 Cd. 2 B. 1 T. A beautiful clear-white alloy, having a very slight roseate tint; free surface, frosted. It is very fusible and very brittle; it breaks with a smooth, compact, steel-like fracture. H. 5. Fl. 1. M. 1. Fu. 2+

1 Cd. 5 B. 4 T. Similar in appearance to the preceding; fracture

*Clouded—Presenting a white opacity, like a white film or cloud.

Frosted—Having the appearance of fine white crystallization, like hoar-frost.

the same. As to fusibility, it has a wide range, being fluid at 240°, and still soft at 220°. H. 5. Fl. 1. M. 1. Fu. 2·4.

68 Cd. 95 B. 216 T. Appearance and fracture like the last. H. 5. Fl. 1. M. 1. Fu. 2·5—3.

5 Cd. 4 B. 140 T. General appearance the same. Free surface, smooth and polished. Very brilliant. Fracture, rough and hackley. H. 5. Fl. 2. M. 2. Fu. 4+ (same as tin).

Cadmium with Lead and Tin.

From these are produced alloys combining the qualities of fusibility and tenacity in an eminent degree, rendering them very desirable as solders—the alloys in general use for this purpose, that melt at as low a temperature, being much more brittle.

The following formulæ (secured by patent, March, 1860) furnish the most fusible form of these alloys:—

1 Cd. 1 L. 2 T. White and glistening. H. 5. Fl. 5. M. 5. Fu. 2·8.

1 Cd. 2 L. 4 T. Resembles the preceding. H. 4. Fl. 5. M. 5. Fu. 2·8.

QUATERNARY COMBINATIONS.

Cadmium with Antimony, Copper, and Tin:

Cadmium in connexion with these metals gives greater hardness to the alloys without materially modifying their other qualities. For this purpose, it should be used in rather small proportions. In the following instances, two parts instead of one do not increase the hardness, while four parts diminish it.

1 Cd. 1 A. 1 Cop. 10 T. produce a very hard yellowish-white alloy, which, though brittle, is strong. It has a fine granular fracture. It casts without shrinkage. Free surface, full and rounded, somewhat crystalline, and has a saffron stain. It is an example of alloys having a wide range between the states of partial and complete fluidity. It softens at the heat which melts bismuth, and is but imperfectly fluid at that which melts lead. H. 7. Fl. 1. M. 2. Fu. 6.

1 Cd. 2 A. 1 Cop. 12 T. This is a still more desirable alloy, being very white and bright, equally hard, and more fusible. It is whiter than silver, being more of a pearl or milk-white color. Free surface, full and round, and finely crystalline. In other respects similar to the last. H. 7. Fl. 1. M. 2. Fu. 5.

Cadmium with Bismuth, Lead, and Tin.

Combined in certain proportions, these metals produce the most fusible alloys known. The compounds which manifest this property most strikingly, have been heretofore described. (They were embraced in letters patent, granted 1860.) It only remains to give a few formulæ for comparison with other alloys.

1 Cd. 1 B. 1 L. 1 T. Equal parts of the metals form a white alloy, rather hard and brittle, breaking with a close-grained fracture. H. 4—5. Fl. 3. M. 4. Fu. 2+

$\left.\begin{array}{l}\text{1 Cd. 4 B. 2 L. 1 T.}\\ \text{1½ Cd. 7½ B. 4 L. 2 T.}\end{array}\right\}$ These are nearly identical in character and properties. In thin plates, they

are flexible, otherwise rather brittle. Color, white, with a faint purplish shade. Fracture, smooth and close-grained. H. 4. Fl. 3. M. 2. Fu. 1·5.

1 Cd. 6 B. 4 L. 2 T. This is similar to the last named, but is preferable for casting purposes. It melts at about 160° F.

1 Cd. 1 B. 4 L. 2 T. H. 4. Fl. 4. M. 4. Fu. 3.

12·08 Cd. 15·75 B. 7·69 L. 4·38 T. This is adduced merely as an instance of a very fusible alloy having a wide range between the points of perfect liquefaction and solidification. Heated by the side of the thermometer bulb, in water, it became soft at 170°, and at 210°—the highest point indicated by the thermometer, the water boiling—nearly fluid, not perfectly, but sufficient to recover from indentations impressed upon it. On cooling, it was at 200° only semi-fluid, so as to retain indentations, still quite soft at 175°, and not perfectly solidified until the mercury fell to 150°.

The uses of the foregoing alloys will be suggested by their qualities.

I may be permitted to repeat, that these experiments were not undertaken with a view to methodical investigation; and these descriptions must fall far short of what in such case would be expected. But having to do with metals, the frequent want of one possessing a particular quality or combination of qualities, led me, from time to time, to experiment with alloys, with a view to their improvement in such particular—noting more especially whatever promised the desired result. In such cases, the development of any unexpected property, and sometimes merely baffled curiosity, naturally stimulated the inquiry beyond its original purpose. But defective as these descriptions may be, it is hoped that, so far as they go, they will be found to give reliable information upon a class of metallic combinations which appear not to have been described hitherto, if examined.

INDIANAPOLIS, Feb. 1, 1862.

For the Journal of the Franklin Institute.

Analysis of the Gamut in the Major and Minor Modes.

By C. J. W., Jr., Germantown, Pa.

The octave of musical sounds, as is well known, is composed of five whole tones and two semitones, or of twelve semitones.

In the major mode, to which we shall first turn our attention, the two semitones are placed between the third and fourth, and the seventh and eighth notes of the scale.

This position of the semitones is dictated by no arbitrary law, as might at first appear, but is determined by the sense of melody inherent in the soul of man: it is indispensable, therefore, that the relationship should be preserved throughout all modulations and transpositions of major keys.

As there is no difference between one octave and another, with regard to the positions of the tones and semitones, any course of reasoning applied to one, applies equally to all, be they pitched high or low; the only difference between a note and its octave, being, that the

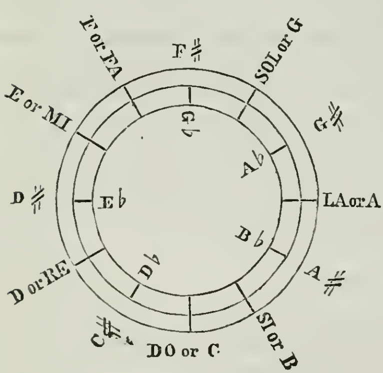
vibration by which the higher note is produced, has twice the velocity of that which produces the lower.

The rule to be observed in modulating from the natural key—the key of Do, or C—into a key represented by flats, is, that the flats shall succeed each other by ascending fourths, or, which is equivalent, by descending fifths, commencing with the seventh of the scale—Si, or B—for the first flat; while in modulating into a key represented by sharps, the rule is reversed, for the sharps must succeed each other by ascending fifths, or descending fourths, commencing with the fourth of the scale—Fa, or F—for the first sharp. Now these rules are entirely dependent upon the law already referred to, controlling the relative positions in the major mode of the tones and semitones of the scale, and though usually dictated without regard to the principles upon which they are based, a brief examination into the manner in which the position of the semitones is affected by the additions in question, will nevertheless render them sufficiently apparent.

Let the annexed diagram, Fig. 1, represent the octave in the key of Do, or C major; the long marks representing the natural notes, and the short marks, the flats or sharps.

The circular form of the diagram is selected as peculiarly adapted to the investigation of the subject before us; ascending or descending octaves being but a repetition of the same notes, ever returning, like the circle, to the point of commencement.

Fig. 1.



By an examination then of this diagram, with a view to modulating into other keys, it will readily be discovered that there are but two notes—the fourth and the seventh of the scale—that can be successfully attacked without disturbing the relative position of the tones and semitones, so necessary to be preserved.

Suppose, for example, we try the experiment of advancing the first note of the scale, Do, one semitone. The interval between the semitones of the octave thus modified, will be reduced, in one direction, to one whole tone—while in the other direction, it will be increased to four whole tones. This distribution of the semitones evidently belongs to no major key whatever, and we cannot therefore commence our modulations by disturbing the *first* of the scale.

In order to complete the modulation now initiated, and to restore the equilibrium of the octave, it will be necessary to increase the interval between the semitones in one direction, and to diminish it in the other. This may evidently be accomplished by advancing the note Fa, a semitone. The interval between Re and Fa sharp, is composed of two whole tones; while the interval from Sol to Do sharp, is

composed of three whole tones. It is evident, therefore, that by taking Re for the keynote, we have modulated into the key of two sharps; but at the same time, it will be observed that the equilibrium of the octave has only been preserved by the modification of two notes, instead of one, as was proposed.

Convinced, therefore, that this is not the initial modulation from the natural scale, we will proceed by trying the effect of augmenting Re, the second of the scale.

The interval between Re sharp and Mi, is but one semitone; we shall thus have three semitones in our scale, two of which are in juxtaposition. It will be readily admitted, therefore, that the second of the scale is not the proper note to attack—observing that the distribution of the semitones can only be re-adjusted by the augmentation of a number of other notes of the scale. For example: Re sharp evidently requires that Fa should be sharpened in order to separate the contiguous semitones; but this is not yet sufficient, for there now exists between the two semitones one full tone, instead of two, as required. It is indispensable, therefore, that Sol should be sharpened. We have now accomplished the necessary condition of two full tones, in one direction, between the semitones; thus there yet remains the redundancy of semitones, however, to disqualify the scale. Further modification, therefore, is still required. Fortunately, this latter difficulty may be easily overcome, but one additional change being requisite. By the removal of Do, to Do sharp, and the assumption of Mi for the keynote, two whole tones will be found to exist between Mi and Sol sharp, and three whole tones between La and Re sharp. Thus the order of the tones and semitones of the scale is fully restored.

It appears, from the above investigation, that the experiment of modulating by the sharpening of the second of the scale, has required the modification of three additional notes before the octave could be restored to its original condition.

By pursuing a similar course, it may be shown that the first and only modulation of a scale, involving the disturbance of no other note, is to be accomplished by applying the modification to its fourth, or seventh. These two, therefore, will be found to be the initial modulations of which we are in search—the one introducing us to a key represented by flats, the other introducing us to a key represented by sharps. It remains to be shown what effect will be produced upon the scale by the application of our modifications to these two notes successively.

It is evident from the position of the semitones of the major scale, that the fourth cannot be flattened, or the seventh sharpened, without becoming identical with other notes of the scale. In view of this, therefore, we shall apply the sharp to the fourth, and the flat to the seventh.

If Fa, the fourth of the natural scale, be augmented by the introduction of a sharp into the signature, the order of the semitones will be precisely reversed, without otherwise interfering with their relative position; the interval between the note Do and the first semitone of

the scale—formerly composed of two full tones—will thus be increased to an interval of three full tones; meanwhile, the interval between the semitone as now placed and the second semitone of the old scale, immediately preceding the fundamental note Do, will be correspondingly decreased, and will comprise but two full tones. It is abundantly evident, therefore, that the note Do can no longer do duty as the keynote of the scale thus modified, but must yield that distinction to some other of its six competitors—it remains to be shown which of these is to become the successful candidate.

Through the inversion of the order of the semitones thus established, the interval between the note Do and the first semitone, is an interval proper to the separation of the first and second semitones of the major scale, and the interval existing between the advanced semitone and the second semitone of the natural scale, is that proper to the separation of the keynote and the first semitone. The first semitone of the original scale, therefore, becomes the final or leading semitone of a new scale, and as in the formation of this semitone the fourth of the old scale was advanced, the note immediately succeeding this, or the fifth, will become the fundamental note. Sol will, therefore, be the keynote of the new scale.

By the arrangement now proposed, the equilibrium of the octave will be seen to be completely restored, and the order of the tones and semitones, in perfect accordance with the principles upon which the major scales are based.

Through the augmentation, therefore, of one single note, we have effected a modulation into a new scale, in which the eighth of the old scale appears as the fourth, and in which the fifth of the old scale appears as the eighth. In other words, by sharpening the fourth of a scale, we have modulated into its dominant.

By pursuing a similar course of investigation, it will be found that the initial modulation to be made from our new key of Sol, is to be accomplished, in like manner, by the augmentation of *its* fourth, thus modulating in turn, into its dominant. For the next scale in order, therefore, we shall have Do, or C sharp, in addition to Fa sharp, and Re, the fifth of the present scale, for the keynote.

The process of sharpening the fourth of each new scale, and thereby producing the scale of its dominant, may be continued until every note of the octave has, in turn, been reached, and we arrive again at the identical point—the key of Do natural (or its equivalent)—from which we originally set out.

Proceeding upon this principle, the modulations represented by sharps will succeed each other in the following order. (See fig. 2.)

It will be seen that the fundamental note of each key is represented by a solid note, such as a crotchet without the stroke, while the dominant and subdominant are represented by open notes, such as a minim. Observe, also, that only the additional sharp of each key appears in the signature, it being perfectly understood, however, that to every key belong all the sharps of the preceding keys, equally with the one introduced.

By reference to the table below, it will be seen that the augmentation of the second of the natural scale—one of the changes proposed in the search for the initial modulation, and rejected on account of the disarrangement of the semitones which it produces—is the fourth, instead of the first, in the order of modulations; and that it requires the introduction of three auxiliary sharps before the equilibrium of the octave can be restored.

Fig. 2.—Table of Progressive Sharps.

This law of succession of sharps by ascending fifths, affords an easy rule for finding the keynote indicated by any number of sharps proposed; or, *vice versa*, for finding the number of sharps required to produce any given keynote without the labor of counting them over in the ordinary way. The latter rule is particularly convenient in its application to the transposition of music.

The rule for the solution of the first proposition is as follows: multiply by four the number of sharps proposed, and divide the product by seven. The remainder will give the number of notes above the keynote of the natural scale, that the keynote required will be found.

For example: suppose it were required to find the keynote of the scale of five sharps.

Here, five multiplied by four, equals twenty, and twenty divided by seven, leaves a remainder of six. Six notes above Do natural, therefore, will the keynote of five sharps be found. Si, or B is the note; and by reference to the table it will be seen to be the keynote of the scale proposed.

Again: suppose the keynote of twelve sharps were required.

In this case twelve is to be multiplied by four, equal to forty-eight. Forty-eight divided by seven, leaves six for a remainder. B is again, therefore, the keynote required; in this instance, however, it will be B sharp—that note having already been sharpened in the scale. But B sharp is practically the same note as C natural—the same key answering for both in all keyed instruments. We have again, therefore, returned to the original key of Do natural.

To the solution of the second proposition—that of finding the number of sharps required to produce any given keynote—may be applied the following rule.

Find the number of notes that the given keynote is placed above the keynote of the natural scale of Do, and if this number is not divisible by four, without a remainder, add thereto the first multiple of seven that will render it so. The number of times that four is contained by this sum will be the number of sharps required.

For example: suppose a piece of music arranged in the key of Fa natural, were required to be raised one full tone; the key sought would then be the key of Sol natural. The question to be solved is to discover the number of sharps that will be required to produce the key of Sol natural.

Sol natural is four notes above Do natural, and four is divisible by four, once. The key of Sol natural requires, therefore, the introduction of but one sharp into the signature.

Suppose, for a second example, that the number of sharps necessary to produce the key of B natural were required. Now B natural is six notes above Do natural, and six added to fourteen—the first multiple of seven, which added to six makes a sum divisible by four, without a remainder—makes twenty, and twenty is divisible by four, five times. Five sharps, therefore, are required to produce the key of B natural.

A brief investigation into the rationale of the rules above applied will render it sufficiently obvious.

In consequence of the nomenclature of accords being in accordance with the number of sounds, and not the number of notes, of which they are composed, each accord gives the impression of containing one note more than is actually embraced within its limits. Thus a second includes but one note, though composed of two sounds; a third includes but two notes, though composed of three sounds; a fourth includes but three notes; a fifth, but four notes, and an octave, but seven notes. As the addition of each sharp to the signature raises the keynote of the scale a fifth, or four notes, the number of sharps introduced, multiplied by the number of notes contained in a fifth, will give the number of notes that the keynote is raised above the keynote of the natural scale; divide this number by the number of notes contained in an octave, and the remainder, if any, will necessarily give the number of notes above Do, that the keynote of the proposed scale will be placed.

The rule suggested for finding the number of sharps required for any given keynote, being but the converse of the one just explained, evidently requires no further demonstration.

Of the introduction of accidental sharps, it is likewise unnecessary to speak; they, only producing temporary modulations of the key, obey the same laws as those already investigated. We shall, therefore, proceed to the consideration of modulations effected by the introduction of flats into the signature.

By referring once more to the circular diagram, and pursuing a course of investigation similar to that already applied to the subject of

sharps, it will be seen, that, as the fourth of the scale is the only note to be sharpened, so the seventh is the only note to be flattened, consistently with the preservation of the relative positions of the tones and semitones of the major octave.

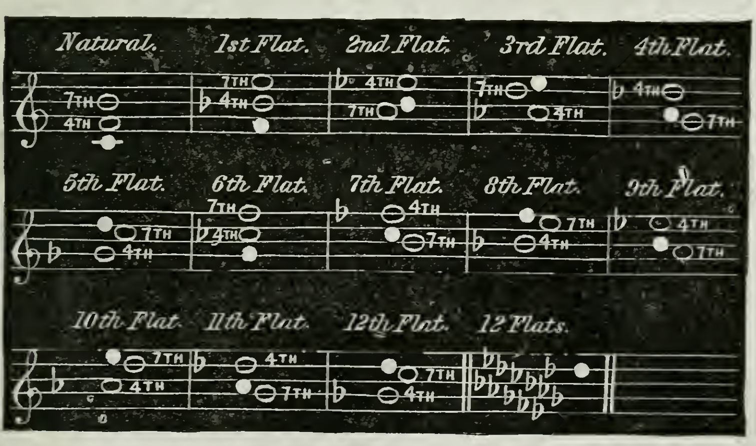
By flattening the seventh, therefore—which in the natural scale is the note Si, or B—we shall evidently diminish the interval before existing between the first and second semitones, by one full tone, in one direction, while at the same time we increase, to a similar extent, the interval existing between them in the other direction. We have thus produced another new scale, in which the first semitone of the old scale—now, by virtue of the change which we have introduced—preceded by three full tones, appears as the last or leading semitone. The note immediately succeeding this semitone must consequently be the fundamental note of the scale. This note is Fa, or F—the fourth or subdominant of the original scale.

By the acceptance of this arrangement the equilibrium of the octave will be fully restored; the tones and semitones occupying their appropriate positions.

Through the diminution, therefore, of a single note, we have produced a new scale, in which the fourth of the original scale appears as the eighth, and in which the seventh appears as the fourth. In other words, by flattening the seventh of the scale we have modulated into its subdominant.

This process of diminishing the seventh may be continued, as in the augmentation of the fourth—until every note of the octave has in turn been reached, and we return practically to the keynote with which we commenced. Each additional flat will form a new scale, the fundamental note of which will be the fourth, or subdominant, of that by which it is immediately preceded.

Fig. 3.—Table of Consecutive Flats.



That flats should succeed each other necessarily, by ascending fourths, thus becomes obvious; for, as the entire scale is elevated a fourth by each additional flat, the seventh of the scale is likewise raised with it—

and, as the seventh of the scale is the note to which the additional flat is invariably applied, the additional flat will unquestionably be a fourth above the one immediately anterior. The previous flat, or last flat but one, thus becomes the keynote of each scale of flats, that being the note immediately following the last semitone. The same principle was shown to determine the keynote in a system of sharps; it being recollected, however, that a flat takes its name from the *succeeding* note, while on the contrary the name of the sharp is derived from the *preceding* note.

The order of modulations by flats is shown in the above table, in which it will be observed, that only the last note flattened in each key is introduced; and also, that the keynote is represented by a solid note, while the fourth and seventh of the various scales are represented by open notes, as in the table of sharps on a preceding page.

The elevation of the keynote by fourths, effected by the addition of flats to the signature, enables us to establish rules for finding the keynote required for any number of flats, as well as the number of flats required for any keynote, precisely similar to those applied to like cases in scales represented by sharps; except, that the number of flats is to be multiplied by three—the number of notes embraced in the interval of a fourth—instead of by four, the number embraced in the interval of a fifth. For example: let it be required to find the keynote indicated by the signature of six flats. Here, six multiplied by three equals eighteen, and eighteen divided by seven leaves a remainder of four. Four notes above Do, therefore, will be the keynote required; thus Sol is the keynote of a scale of six flats. But the keynote of any scale of flats has been shown to be the last flat but one in the signature. This note Sol, therefore, has been flattened in the antecedent modulation of the series. Sol *flat* is consequently the keynote of six flats.

It would evidently be superfluous to introduce any demonstration of this latter rule, as it would merely be a reiteration of the steps already taken, when upon the subject of modulations effected by sharps.

As an example of the converse of the proposition, suppose it were required to find the number of flats indicated by the keynote of La, or A flat. Now La is five notes above Do; five added to seven equals twelve, and twelve is divisible by three four times. Four flats, therefore, are required to produce the key of La flat.

Without further multiplication of examples, we shall now turn our attention to the subject of identical keys.

(To be Continued.)

Mode of Repairing the Silvering of Looking-Glasses.

The following notice is from *Dingler's Polytechnisches Journal:*—The mending of the silvering of looking-glasses is considered a very difficult operation. Recently, however, a method has been described in the Polytechnic Society of Leipsic, which several trials recommend as simple and practical. When the silvering is damaged, the place is

uncovered and cleaned by gentle rubbing with fine cotton until there is no trace of dust or grease. This cleansing must be done with the greatest care, if we would not leave a stain around the place. Then, with the point of a knife, a piece is cut from the silvering of another glass,* of the same shape with that removed, but rather larger. A small globule of mercury (for instance, the size of a pin's head for a surface the size of the finger-nail) is dropped upon the cut piece. The mercury immediately spreads, penetrates the amalgam as far as the cut, and allows the piece to be removed, and put on the desired place. This manipulation is the most difficult part of the work. It is then gently pressed on the spot with cotton; it soon hardens, and the glass looks as if it were new.—*Cosmos.*

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 120.)

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 46{\cdot}65 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formulæ, $W = 46{\cdot}65 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \frac{W c}{W + \frac{3}{4} c}$.	Calculated breaking weight per square inch in tons.
7½	6½	4¾	13·846	362·79		432·81	27·99
9	"	"	16·615	435·35		374·47	24·21
10½	"	"	19·384	507·91		325·20	21·03
12½	"	"	23 076	604·66		271·69	17·57
15	"	"	27·692	725·59		220·34	14·24
17½	"	"	32·307	846·52		181·72	11·75
20	"	"	36·923	967·45	147·92		9·56
30	"	"	55·384	1451·18	74·24		4·80
					$W = 42{\cdot}347 \frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$.	$W = 42{\cdot}347 \frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$ $Y = \frac{W c}{W + \frac{3}{4} c}$.	
6	7	5	10 2-7	353·81		622·70	33 03
8	"	"	13 5-7	471·75		521·12	27·64
10	"	"	17 1-7	589·69		437·49	23·20
12	"	"	20 4-7	707·62		370·08	19·63
14	"	"	24	825 56		315·99	16·76
16	"	"	27 3-7	943·50		272·41	14·45
18	"	"	30 6-7	1061·44		237·04	12·57
20	"	"	34 2-7	1179·38	201·41		11·03
22	"	"	37 6-7	1297·31	172·43		9·14
24	"	"	41 1-7	1415·25	149 63		7·93
26	"	"	44 4-7	1533·19	131·33		6·96
28	"	"	48	1651·13	116 38		5 17
30	"	"	51 3-7	1769·07	104·00		5·51

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9\frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formulæ, $W = 14{\cdot}9\frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars, same dimensions, with *flat* ends.
6	7	10 2-7		810·60	21·06	1·39
8	"	13 5-7		596·19	15·49	1·50
10	"	17 1-7	447·45		11·62	1·61
12	"	20 4-7	328·20		8·52	1·80
14	"	24	252·54		6·56	1·94
16	"	27 3-7	201·25		5·22	1·96
18	"	30 6-7	164·73		4·28	1·96
20	"	34 2-7	137·71		3·57	1·96
6	8	9		1202·33	23·91	1·32
8	"	12		908·88	18·08	1·43
10	"	15		703·96	14·00	1·51
12	"	18	542·25		10·78	1·63
14	"	21	417·24		8·30	1·69
16	"	24	332·51		6·61	1·89
18	"	27	272·17		5·41	1·91
20	"	30	227·53		4·52	1·91
6	9	8		1682·96	26·45	1·27
8	"	10 2-3		1304·39	20·50	1·37
10	"	13 1-3		1028·46	16·16	1·45
12	"	16		827·10	13·00	1·51
14	"	18 2-3	649·70		10·21	1·63
16	"	21 1-3	517·76		8·13	1·76
18	"	24	423·81		6·66	1·86
20	"	26 2-3	354·30		5·56	1·86
6	10	7·2		2253·22	28·68	1·23
8	"	9·6		1786·18	22·74	1·32
10	"	12		1432·14	18·23	1·39
12	"	14·4		1166·12	14·84	1·46
14	"	16·8		964·67	12·28	1·51
16	"	19·2	769·45		9·79	1·63
18	"	21·6	629·84		8·01	1·74
20	"	24	526·53		6·70	1·82
6	11	6 6-11		2912·80	30·65	1·19
8	"	8 8-11		2356·24	24·79	1·27
10	"	10 10-11		1918·94	20·19	1·35
12	"	13 1-11		1581·19	16·63	1·41
14	"	15 3-11		1320·00	13·88	1·45
16	"	17 5-11	1101·08		11·58	1·52
18	"	19 7-11	901·30		9·48	1·63
20	"	21 9-11	753·46		7·92	1·72
6	12	6		3661·05	32·37	1·17
8	"	8		3015·58	26·66	1·24
10	"	10		2491·65	22·03	1·31
12	"	12		2076·43	18·35	1·36
14	"	14		1748·80	15·46	1·41
16	"	16		1489·09	13·16	1·46
18	"	18	1250·12		11·05	1·53
20	"	20	1045·06		9·24	1·62

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$.	Calculated breaking weight in tons from formulæ, $W = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$, $Y = \frac{W c}{W + \frac{3}{4} c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars, same dimensions, *rounded* ends.
6	7	10 2-7		1126·87	29·28	1·39
8	"	13 5-7		898·74	23·35	1·50
10	"	17 1-7		723·93	18·81	1·61
12	"	20 4-7		591·52	15·37	1·80
14	"	24		490·63	12·74	1·94
16	"	27 3-7	396·38		10·29	1·96
18	"	30 6-7	324·46		8·43	1 96
20	"	34 2-7	271·24		7·04	1·96
6	8	9		1591·59	31·66	1·32
8	"	12		1301·19	25·88	1·43
10	"	15		1068·65	21·26	1·51
12	"	18		886·34	17 63	1·63
14	"	21		705 91	14·04	1·69
16	"	24		631·38	12·56	1·89
18	"	27	521·23		10·36	1·91
20	"	30	435·74		8·66	1·91
6	9	8		2140·76	33·65	1·27
8	"	10 2-3		1787·55	28·09	1·37
10	"	13 1-3		1493·63	23 47	1·45
12	"	16		1255·95	19·74	1·51
14	"	18 2-3		1065·36	16·74	1·63
16	"	21 1-3		912·33	14·34	1·76
18	"	24		788·67	12·39	1·86
20	"	26 2-3	661·96		10·40	1·86
6	10	7·2		2773·82	35·31	1·23
8	"	9·6		2358·41	30·02	1·32
10	"	12		2001·00	25·47	1·39
12	"	14·4		1703 82	21·69	1·46
14	"	16 8		1460·05	18·58	1·51
16	"	19·2		1260·67	16·05	1·63
18	"	21·6		1097·16	13·96	1·74
20	"	24		962·17	12·25	1·82
6	11	6 6-11		3490·08	36 72	1·19
8	"	8 8-11		3013 88	31·71	1·27
10	"	10 10-11		2592·06	27·27	1·35
12	"	13 1-11		2232 45	23·49	1·41
14	"	15 3-11		1931·24	20·32	1·45
16	"	17 5-11		1680·59	17·68	1·52
18	"	19 7-11		1472·06	15·48	1·63
20	"	21 9 11		1297·91	13·65	1·72
6	12	6		4288·92	37·92	1 17
8	"	8		3753·75	33·19	1·24
10	"	10		3267·47	28·89	1·31
12	"	12		2843·51	25·14	1·36
14	"	14		2481·54	21·94	1·41
16	"	16		2175·42	19·23	1·46
18	"	18		1917·27	16·06	1·53
20	"	20		1699·22	15·02	1·62

Mr. Hodgkinson says, "The index of the power of the diameter, to which the strength of long pillars of cast iron, with rounded ends, is proportional, is 3·76, nearly, and 3·55 in those with flat ends; as appeared from means between the results of a great number of experiments; or the strength of both may be taken as following the 3·6 power of the diameter, nearly."

"In cast iron pillars of the same thickness, the strength is inversely proportional to the 1·7 power of the length, nearly."

"It has been stated that the strength of solid pillars with rounded ends, varied as $\frac{d^{3.76}}{l^{1.7}}$, and that of those with flat ends as $\frac{d^{3.55}}{l^{1.7}}$. This was when the former pillars were not shorter than about 15, nor the latter than about 30 times the diameter."

"In the research for the above numbers, I was led to conclude that, if the material had been incompressible, the 3·76 and 3·55 would each have become 4, and the 1·7 have been 2. In that case, the strength would have varied as $\frac{d^4}{l^2}$, which is the ratio of the strength of pillars according to the theory of Euler; which theory was intended to apply to the power of pillars to resist incipient flexure, whilst my inquiry was as to the breaking strength."

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9 \frac{D^{3\cdot6}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formulæ, $W = 14{\cdot}9 \frac{D^{3\cdot6}}{L^{1\cdot7}}$. $Y = \frac{Wc}{W + \frac{3}{4}c}$.	Calculated breaking weight per square inch in tons.	Ratio of strength of pillars of same dimensions with *flat* ends.
5	2	30	11·71		3·72	2·96
8	"	48	5·26		1·67	2·96
14	"	84	2·03		0·64	2·96
20	"	120	1·10		0·35	2·96
5	3	20	50·41		7·13	2·50
8	"	32	22·67		3·20	2·96
14	"	56	8·75		1·23	2·96
20	"	80	4·77		0·67	2·96
6	4	18	104·16		8·28	2·36
8	"	24	63·87		5·08	2·80
10	"	30	43·71		3·47	2·96
14	"	42	24·67		1·96	2·96
20	"	60	13·45		1·07	2·96
6	5	14·4	232·60		11·84	2·02
8	"	19·2	142·63		7·26	2·49
10	"	24	97·60		4·97	2·82
12	"	28·8	71·59		3·64	2·96
14	"	33·6	55·08		2·80	2·96
16	"	38·4	43·90		2·23	2·96
18	"	43·2	35·93		1·82	2·96
20	"	48	30·04		1·52	2·96
6	6	12		417·63	14·77	1·86
8	"	16	274·96		9·72	2·21
10	"	20	188·15		6·65	2·57
12	"	24	138·01		4·88	2·83
14	"	28	106·19		3·75	2·96
15	"	30	94·44		3·34	2·96
16	"	32	84·63		2·99	2·96
18	"	36	69·27		2·44	2·96
20	"	40	57·91		2·04	2·96

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9\frac{D^{3\cdot6}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formulæ, $W = 14{\cdot}9\frac{D^{3\cdot6}}{L^{1\cdot7}}$ $Y = \frac{W c}{W + \frac{3}{4}c}$.	Calculated breaking weight per sq inch in tons.	Ratio of strength of pillars of same dimensions with *flat ends*.
12	7	20 4-7	240·39		6·24	2·62
16	"	27 3-7	147·40		3 83	2·96
20	"	34 2-7	100·87		2·62	2·96
12	8	18	388·78		7·73	2·43
16	"	24	238·40		4·74	2 85
20	"	30	163·13		3 24	2·96
12	9	16	594·08		9·33	2·25
16	"	21 1-3	364·29		5 72	2·70
20	"	26 2-3	249·28		3·91	2·96
16	10	19·2	532·33		6·77	2·55
20	"	24	364·27		4·63	2·87
16	11	17 5-11	750 24		7·89	2·41
20	"	21 9-11	513·38		5·40	2·75
16	12	16	1026·20		9·07	2·28
20	"	20	702·22		6·20	2 63

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Flat, as deduced from Mr. Hodgkinson's Formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16\frac{D^{3\cdot6}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formulæ, $W = 44{\cdot}16\frac{D^{3\cdot6}}{L^{1\cdot7}}$ $Y = \frac{W c}{W + \frac{3}{4}c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars of same dimensions with *rounded ends*.
5	2	30	34·71		11 04	2·96
8	"	48	15·61		4·96	2·96
14	"	84	6·02		1·91	2·96
20	"	120	3·28		1 04	2·96
5	3	20		126·47	17·89	2·50
8	"	32	67·20		9·50	2·96
14	"	56	25·95		3·67	2·96
20	"	80	14·15		2·00	2·96
6	4	18		246·70	19 63	2·36
8	"	24		179·02	14·24	2·80
10	"	30	129·54		10·30	2 96
14	"	42	73·11		5 81	2 96
20	"	60	39·87		3·17	2·96
6	5	14 4		470·08	23·94	2·02
8	"	19·2		355·42	18·10	2·49
10	"	24		275·33	14·02	2·82
12	"	28 8	212·18		10·80	2·96
14	"	33·6	163 27		8·31	2·96
16	"	38·4	130·11		6·62	2·96
18	"	43·2	106·50		5·42	2·96
20	"	48	89·03		4·53	2·96

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Flat, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16\frac{D^{3\cdot6}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formulæ, $W = 44{\cdot}16\frac{D^{3\cdot6}}{L^{1\cdot7}}$. $Y = \frac{W c}{W + \frac{3}{4}c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars of same dimensions with *rounded* ends.
6	6	12		777·51	27·49	1·86
8	"	16		608·95	21·53	2·21
10	"	20		483·85	17·11	2·57
12	"	24		391·33	13·84	2·83
14	"	28	314·74		11·13	2 96
15	"	30	279·91		9·89	2·96
16	"	32	250 82		8·87	2·96
18	"	36	205·31		7·26	2·96
20	"	40	171·63		6·07	2·96
12	7	20 4-7		631·71	16·41	2·62
16	"	27 3-7	436·88		11·35	2·96
20	"	34 2-7	298·95		7·76	2·96
12	8	18		946·16	18·82	2·43
16	"	24		681·43	13·55	2·85
20	"	30	483·49		9·61	2·96
12	9	16		1339·12	21·04	2·25
16	"	21 1-3		984·79	15·47	2·70
20	"	26 2-3	738·82		11·61	2·96
16	10	19 2		1360·13	17·31	2·55
20	"	24		1047·62	13·33	2·87
16	11	17 5-11		1811·41	19 06	2·41
20	"	21 9-11		1413·07	14·86	2·75
16	12	16		2341·62	20·70	2·28
20	"	20		1849 02	16·34	2·63

Solid Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Side of the square in inches.	Number of diameters contained in the length or height.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formula, $W = 10{\cdot}95\frac{D^4}{L^2}$.	Calculated breaking weight in tons from formulæ, $W = 10{\cdot}95\frac{D^4}{L^2}$ $Y = \frac{W c}{W + \frac{3}{4}c}$.
18	8	27	7·999	377·39		100·54
19	"	28 5	8·443	398·36		94·65
20	"	30	8·888	419·32		89·15
21	"	31·5	9 332	440·29		84·01
22	"	33	9·776	461·26		79·22
23	"	34·5	10·221	482 22		74·77
24	"	36	10 665	503·19		70 62
25	"	37·5	11·110	524·16		66·78
26	"	39	11·554	545·12		63·15
27	"	40·5	11·998	566 09		59·81
28	"	42	12·443	587 05		56·69
29	"	43 5	12 887	608·02	53·33	
30	"	45	13·332	628·99	49·83	

Solid Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Side of the square in inches.	Number of diameters contained in the length or height.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formula, $W = 7{\cdot}81 \frac{D^4}{L^2}$.	Calculated breaking weight in tons from formula, $W = 7{\cdot}81 \frac{D^4}{L^2}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.
18	8	27	7·999	348·36		77·45
19	"	28·5	8·443	367·71		72·57
20	"	30	8·888	387·07		68·05
21	"	31·5	9·332	406·42		63·87
22	"	33	9·776	425·77		60·01
23	"	34·5	10·221	445·13		56·44
24	"	36	10·665	464·48		53·13
25	"	37·5	11·110	483·84		50·05
26	"	39	11·554	503·19		47·24
27	"	40·5	11·998	522·54	43·88	
28	"	42	12·443	541·90	40·80	
29	"	43·5	12·887	561·25	38·03	
30	"	45	13·332	580·60	35·54	

(To be Continued.)

ERRATA.—In the January number, page 42, first table at top of page—Table showing one-tenth of the breaking weight in tons—diam. 7 ins., height 12 ft., weight 63·91 tons, read weight 59·15 tons. Second table from top—Table showing one-fourth of the breaking weight in tons—diam. 7 ins., height 12 ft., weight 159·79 tons, read weight 147·88 tons. Fourth table from top—Solid uniform cylindrical pillars, &c.,—height 12 ft., diam. 7 ins., breaking weight 639·16 tons, read breaking weight 591·52 tons.

Improvement in Telegraph Cables.—Specification of the Patent granted to THOMAS WILLIAM EVANS, M. D., of the City of Paris, France, for Improvements in Telegraphic Cables.—Dated March 7, 1861.

From the Repertory of Patent Inventions, Jan., 1862.

In constructing electric telegraph cables, I employ a conductor composed of several wires drawn from metal rendered absolutely pure by a process analogous to that employed in the refining of the precious metals, or by any other process of refining. As copper possesses nearly seven times greater electrical conductibility than iron, I adopt copper as the constituent metal of the wire conductor. By the increase of purity, the tenacity, and consequently the conductibility, of the wire, is largely augmented. Recognising the well known electrical law, that the capacity of condensation is in exact ratio with the superficial surface of the conductor, and impressed with the serious risk involved in the employment of a submarine electric conductor composed of only a single wire, I combine seven copper wires (drawn from perfectly pure metal) six of which surround the remaining one as a centre. Having first placed these wires in parallel lines in close contact with each other, I draw them altogether through a round-holed draw plate. By this means I reduce the volume, and compel the wires to assume the form of longitudinal sections of a prolonged cylinder, the

exposed surface of which will be of course exactly equal to that of a single wire of the same diameter, while additional strength and additional safety from risk of total rupture are effectually secured by the use of independent wires. Upon the cylindrical conductor thus prepared I superimpose, to guard against the possibility of any defects in the metal, by means of a galvanic battery, and a bath containing either copper or gold in solution, a slight coating or plating of pure copper or gold (the latter I prefer). By thus presenting a surface of absolutely pure metal, the facility of electrical transmission is sensibly increased, whilst the danger of any chemical action upon the conductor from the contact of the insulation is entirely avoided.

It is a well known fact that when caoutchouc, vulcanized in the ordinary manner with heat, is applied in direct contact with the copper, a chemical effect is produced on the metal, which is rapidly corroded and rendered brittle. It has been attempted to avoid this action by coating the wire with tin and silk or cotton, but the tin is also corroded, and the silk or cotton by capillary attraction absorbs the sulphur, thus communicating it to the wire; now pure caoutchouc over a gold surface has no such effect. For insulating the conductors of electric telegraph cables, I employ three distinct coats, an interior one of pure caoutchouc, a second of gutta percha, and a third of caoutchouc.

Regarding the total exclusion of air as a matter of absolute necessity to the effectual working of submarine cables in great sea depths, I effectually secure this important result by a simple and beautiful adaptation of forces existing in nature. For the interior coat I employ pure caoutchouc unmixed with any other material. From thin sheets of india-rubber I cut long narrow bands, which are then united end to end, and stretch to such a degree as to lose their elasticity; this inelastic gum cord is then wound upon bobbins, and from these bobbins it is rolled off by simple machinery upon the metallic wire conductor, already prepared in the same manner that the large brass strings of musical instruments or ordinary insulated wire employed in electro-magnetic batteries are manufactured. Over this a second coating of gutta percha in a semi-liquid state is imposed, and upon this is placed a third coating of caoutchouc, either pure or combined with pulverized glass, feldspar, sand, or other non-conducting substances. This is vulcanized by passing it through a bath of sulphide of carbon, or the cold process of vulcanizing. When these three insulating coats have been placed in the manner above mentioned, the conductor, thus coated, is passed through a chamber heated to a gentle heat, and by this means the following results are obtained:—The gutta percha gradually softens and forms a complete solder between the two coats of caoutchouc, whilst at the same moment the inner coating of spun caoutchouc, which when cold remains in its inelastic state, endeavors to assume its normal contracted condition before being subjected to stretching. It consequently, by the nature of its being, swells largely, and thus determines an enormous and continued pressure upon the wire conductor. Thus two important results are attained, namely, the solid union of all the coats of the insulation, and the total exclusion

of air. A conductor thus insulated I cover with an external envelope of hemp or other fibrous material wrought in the usual fashion of ships cordage.

By the combination I can let the wires run together in parallel lines to save bulk, and then let one or more branch off to different stations. It is especially useful for telegraph lines passing over the tops of houses. The combined wires being so compact they make an economy of the outer covering, be it what it may, as there is no loss of substance in the interstices between the wires.

I claim the constructing the conductors of electric telegraph cables by combining several wires together, as herein described, not only for submarine, but also for ordinary telegraphs.

I also claim the covering the wire conductors with gold, both in constructing submarine and ordinary telegraph cables.

And I also claim the insulating the conductors of electric telegraphic cables as herein described.

Silvering Glass and other surfaces.—Specification of the Patent granted to John Cimeg, of the County of Middlesex, England, for Improvements in Silvering Glass and other surfaces.—Dated March 13, 1861.

From the Repertory of Patent Inventions, Jan., 1862.

This invention has for its object improvements in silvering glass, and other surfaces. For this purpose I employ a mixture of ammonia, nitrate of silver, with a solution of Rochelle salt (tartrate of potash and soda); this mixture is applied to the surface of glass to be silvered, and after a short time the silver is deposited on the glass as a bright film. The silver is deposited at the ordinary temperature of the air; thus it is not necessary to heat the surface, as when other mixtures are employed. The film of silver may be strengthened by depositing over it a cheaper metal, such as copper. The process above described is also applicable for silvering other surfaces; it is, for example, very useful for giving a metallic and conducting surface to articles on to which it is desired to deposit copper by electricity, and where the article itself is not a conductor of electricity.

In order to silver the surface of paper, or of a woven fabric, or other similar surface, I first deposit the silver on to a polished surface, such as glass; then attach the fabric thereto by suitable cement, and carefully strip the fabric, together with the silver, from the polished surface. In some cases, I obtain an ornamental effect by depositing the silver on a surface on which a pattern has been produced by dulling a portion of the surface.

And in order that my said invention may be most fully understood and readily carried into effect, I will proceed to describe minutely the manner in which I prefer in practice to conduct the processes.

In order to silver a sheet of glass, I place the said sheet, previously washed clean with water, on a table, and rub the whole surface of the sheet with a rubber of cotton or other soft fabric wetted with distilled

water, and afterwards with a weak solution of Rochelle salt in distilled water, about one part of salt in 200 parts of water. I then take a solution, previously prepared by adding nitrate of silver to ammonia of commerce; the nitrate of silver being very gradually added until a brown precipitate commences to be produced, and the solution is then filtered.

For each square yard of glass to be silvered, I take as much of the above solution as contains twenty grammes (about 309 grains) of nitrate of silver, and to this I add as much of a solution of Rochelle salt in distilled water as contains fourteen grammes of salt, and the strength of this latter solution should be so adjusted to that of the silver solution that the total weight of the mixture of the two in the quantities above mentioned, may be sixty grammes. In a minute or two after the mixture is made, it begins to become turbid, and it is then immediately to be poured over the surface of the glass, which has previously been placed on a perfectly horizontal table, but the plate is blocked up at one end, so as to give it an inclination of about one in forty; the liquid is poured on to the plate, along the higher edge, and it runs towards the lower; the pouring is done in such a manner as to distribute the liquid over the whole surface of the plate, without allowing any to escape at the edges. When this is effected, the plate is placed in a horizontal position, at a temperature of about sixty-eight degrees Fahrenheit. The silver will begin to appear in about two minutes. Before the end of ten minutes the plate will be covered, and in thirty minutes sufficient silver will be deposited; this is about two grammes of silver per square yard, which is enough for most purposes. The mixture is then poured off the plate, and the silver it contains is afterwards recovered. The silvered surface of the glass is then washed by pouring water over it four or five times, and the plate is set up to drain and dry. When dry, the silvered surface is varnished by pouring over it (in the same way as the mixture is poured on, as already described) a varnish, composed of the following materials, viz:—

Gum damar,	20	parts.
Asphalte (bitumen of Judea),	5	"
Gutta percha,	5	"
Benzine,	75	"

This varnish dries and sets hard on the surface, and the glass is then ready for framing, or otherwise for use as may be required. When a surface of glass has been silvered as above described, a layer of copper may be deposited over the silver by the ordinary electrotype process, or otherwise, as is well understood. I do not, however, prefer to do this when the object is to obtain a silvered glass, but in some cases I deposit a considerable thickness of copper on to the silver, and then strip the copper and silver together from the glass, which will be done with facility when the coating of copper is thick. In this manner a sheet of any size of plated copper may be produced, plates of other non-absorbent materials (which will not act chemically on the silver solution) may be coated with silver in the same manner as plates of

glass. When it is desired to give a metallic and conducting surface to an article which it is desired to electrotype, say, for example, a medallion of wax or gutta percha, I silver it as already described, sufficient of the silvering mixture being employed to cover every part of the surface. In order to silver paper, woven fabrics, and other materials according to my invention, I, as already mentioned, strip the silver from the surface on which it is deposited by attaching to it the paper, woven fabric, or other similar material, and then removing the said material and the silver film together from the surface. The silver is first deposited, by preference as already described, but it may be otherwise, on to a surface, by preference of glass, then on to the silvered surface is poured in the manner already set out a varnish consisting of gum lac dissolved in wood spirit, one part of gum lac to from six to ten of wood spirit. When this varnish is dry and hard, a solution of one part of gelatine in from six to ten of water is also poured over, and allowed to set into a jelly; the paper, leather, or woven fabric, or other similar material to be silvered, is laid on and pressed in contact with the jelly, and it is then left to dry thoroughly; afterwards the material with the fabric is stripped from the surface, and the process is complete.

On the Carburation of Gas.

From the Lond. Chemical News, No. 105.

The following report has been addressed to the Commissioners of Sewers of the City of London, by their Engineer, Mr. W. Haywood.

"In pursuance of the resolution of the Court of the 23d of April last, I have directed an experiment with the view of testing the value of the application to the public lamps, of the process patented by the United Kingdom Carburating Gas Company.

"The patent of this Company is for placing near to the gas burners a receptacle containing coal naphtha; the gas passing through or over this takes up, and becomes enriched by the addition of the volatile hydro-carbons contained in the naphtha, and the illuminating power of the gas is thereby increased; the quality of the naphtha employed determines mainly the degree of illuminating power gained, and the chemical and photometrical experiments laid before me show that it varies from 25 per cent. to 77 per cent. (See Appendix.)

"The experiment being one in which the gas companies are much interested, I applied to the Chartered Company, who light Moorgate Street, suggesting their co-operation in conducting it with me; the suggestion was at once acceded to, and their Inspector, Mr. Johnson, was placed in communication with me for that purpose.

"Moorgate Street was selected as being well adapted for the experiment, there being an equal number of lamps upon each side of the way, but one or two private lamps only in the street, and but few shops; the street is, therefore, after an early hour of the evening, almost entirely without artificial light, excepting that which it derives from the public gas-lights.

"The patentees stating that, by the application of their process, equal light would be given with half the ordinary consumption of gas, the burners were regulated accordingly.

"The lamps experimented upon were twelve in number, six upon the western side, which were fitted with the ordinary bats-wing burners, calculated to consume upon the average of the night, 5 cubic feet of gas per hour, and six upon the eastern side, fitted with bats-wing burners, calculated to consume 2½ cubic feet per hour. The latter burners having attached to them the carburating apparatus of the Company, each of the twelve burners had a metre attached to it, to ascertain the actual consumption. No pressure regulators were fixed upon the lamps.

"The registration commenced upon the 19th of June, and terminated upon the 19th of July inst., the experiment extending therefore over thirty nights, and gave the following results:—

"That the burners without the carburating apparatus consumed about 4·39 cubic feet per hour.

"That the burners fitted up with the carburating apparatus consumed 2·09 cubic feet per hour.

"No photometer was employed, the equalization of the amount of light given by the two classes of burners was a matter of judgment. The District Inspector of the Commission who saw the lights nightly, reports his opinion that the light given was perfectly equal, and that his opinion is strengthened by collecting those of certain residents in the neighborhood. My own opinion is that the light of the 2½ feet burners was upon the average of the month inferior, although but very slightly so, to that of the 5 feet burners. The Inspector of the Chartered Company coincides with me in this.

"No chemical analysis was made of the naphtha used; but it is stated by the patentees to have been of the best quality.

"My deduction from the experiment is, that with naphtha of equal quality to that used, during the warm months of the year 3 cubic feet of carburated gas may be considered as about equal to 5 cubic feet of gas not carburated.

"Assuming this to be data applicable to all seasons of the year, I have estimated the saving to be effected by the process, and, after allowing for the cost of the apparatus, and for periodically filling it with naphtha, and, after giving credit at the present price of the gas supplied to the public lamps for the quantity not consumed, it shows that the reduction in the cost of each public lamp will be at least £1 per annum; and there being 2825 lamps within the City, that a saving of £2825 would be annually effected.

"The only disadvantage observed during the experiment, was that the reservoir, as constructed, throws a disk of shadow round the base of the gas-lamp standard, but the depth of shadow is but slight; this disadvantage may be largely rectified by an alteration in the form of apparatus.

"It should be understood that I do not pledge myself to any of these figures as exact, for the experiment as conducted cannot lay

claim to be minute or exact in its character; but I believe it may, nevertheless, be taken as giving a close approximation to the truth; it is the mean of the rough results of practice, and the refined processes of the laboratory, from which reliable data are generally drawn; in this case, the results of the experiment are supported by laboratory experiments, and consequently there seems but little doubt that this mode of applying naphtha to the public lights (for the naphthalization of gas itself is by no means new) may lead to a considerable reduction in the cost of public lighting; but what that reduction ultimately would be, would depend upon points which can only be determined by the application of the process to a considerable number of lamps for some length of time, and at different seasons."

The following is Dr. Letheby's Appendix to the above report:—

"The apparatus consists of a chamber for holding coal naphtha, and of a contrivance for directing the stream of gas over the surface of the naphtha. By this means, the gas becomes charged with volatile hydro-carbons, and acquires a higher illuminating power.

"Three sets of experiments were made for the purpose of determining the value of the apparatus. In the first set, a naphtha rich in benzole was employed, and the results were, that at first it raised the illuminating power of ordinary twelve-candle gas to twenty-four candles, and in the course of three days the power fell to eighteen candles, the mean of the whole being twenty-one candles. This is an increase of 77 per cent., and it was effected by giving 10·77 grains of naphtha to each cubic foot of gas.

"In both of the other sets of experiments, an inferior kind of naphtha was used, and, in one case, the average increase of illuminating power, during a period of ten days, and after the passage of a thousand cubic feet of gas, was 25 per cent. In the other case, after a duration of five days, the average increase was 30 per cent. The former was effected by the addition of four grains of naphtha vapor to each cubic foot of gas, and the latter by 6·56 grains.

"These data are sufficient to indicate the general capabilities of the apparatus; for they show that with a good naphtha, supplied in proper quantity, and furnishing from ten to eleven grains of vapor to each cubic foot of gas, the illuminating power of an inferior gas may be nearly doubled. A less volatile naphtha, giving only from four to seven grains of vapor per cubic foot, will increase the power of twelve-candle gas from 25 to 30 per cent. I am, therefore, of opinion, that the apparatus is of practical value as a carburetting agent, and that, if supplied with good naphtha in proper quantity, there will be no difficulty in sustaining a power of twenty candles with ordinary coal gas."

Upon receiving this Report and Appendix, the Commissioners of Sewers resolved that it should be referred to the Engineer and Medical Officer of Health, to consider the conditions of the contracts for public lighting; having special reference to the increased illuminating

power of the gas to be supplied, and to the possibility of carburating the gas by the process of the Carburating Company.

These gentlemen, Dr. Letheby and Mr. Haywood, have now reported upon this subject in the following terms:—

"Before considering the general conditions of a contract, it is necessary first to obtain the determination of your honorable Board to the leading principles upon which the contract should be framed, and it is to those we now specially address ourselves.

"As regards that portion of the reference which relates to the possible reduction of the consumption of gas in the street lamps, we are of opinion that, if the carburating process is not applied, the increase of the illuminating power proposed by the Metropolis Gas Act of 1861, does not render it expedient to diminish the amount of gas to be supplied at the burners of the public lamps; and that the contract should therefore remain as heretofore in this respect, unless the Companies alter the quality of the present supply, and furnish Cannel gas to the public lamps, as the Act of Parliament empowers them to do: under which circumstances it will be necessary to re-adjust the contract and mode of supply accordingly.

"With regard to the carburating process, we are of opinion, from the data obtained by the laboratory experiments quoted in the report to the Commission of the 30th July last, and the experiments made on the public lamps in Moorgate Street, during the months of June and July last, that the process of carburation appears to be capable of economizing the use of gas in the public lamps, to the extent of from 40 to 50 per cent. This conclusion is founded on the assumption that the best quality of naphtha is to be used, namely, a naphtha which will give to the gas continuously a proportion of about ten grains of volatile hydro-carbon to each cubic foot of gas: these being the average results of the laboratory experiments. If an inferior kind of naphtha be employed, the results will be less satisfactory; for the laboratory experiments show that a naphtha yielding four grains of volatile hydro-carbon will increase the illuminating power of the gas only to about from 15 to 20 per cent. . .

"It is manifest, therefore, that the practical efficacy of these results will be entirely dependent on the perfection of the apparatus and the quality of the naphtha, and we are of opinion that these essential conditions can only be secured during the earlier application of the process by an arrangement with the Carburating Company for the supply of the apparatus and the naphtha, as also for the maintenance of the same in complete working order, according to the terms of a contract founded on the preceding data, namely, that a burner consuming three feet of the naphthalized gas per hour, shall give continuously the light of a burner consuming five feet per hour of the same gas not naphthalized; and to secure this, the naphtha should be of such quality as to furnish continuously not less than seven grains of volatile hydro-carbon to each cubic foot of the gas. If the company is willing to undertake such a contract upon suitable terms, we see no difficulty in the practical application of the system.

"If these suggestions are adopted, it will be necessary to contract both with the Gas Companies and the Carburating Company; the terms of such contracts, which should have due relation to each other, must be a matter for future consideration."

Bath for High Temperatures. By Emerson Reynolds.

From the London Chemical News, No. 106.

Some time ago, having occasion to use a bath capable of affording a temperature considerably above that of boiling water, my friend Mr. Tichborne suggested to me the use of glycerine instead of the ordinary saline baths. I tried a mixture of glycerine and water, and found it to answer so well the purpose for which it was intended, that I thought it would be worth while to make known a few particulars which might prove useful to chemists.

I found the boiling-point of a mixture of six parts water with one part glycerine (by measure), to be about 218° F.; with equal parts glycerine and water, 230°; and by using six parts glycerine with two of water, the temperature was raised to and remained steady at 250°. If the proportion of glycerine be much increased beyond this point, acrid fumes are given off on heating the mixture.

The glycerine which I used in these experiments, though otherwise pure, had frequently been accidentally exposed to the air, and had, doubtless, absorbed some moisture from the atmosphere; therefore, the results given above may be looked upon as correct for the mixtures experimented upon, though perhaps they may not hold good when other samples of glycerine are used.

Weisbach's Formula for Finding the Head due to the Friction of Water in Pipes.

From the Civ. Eng. and Arch. Jour., Dec., 1861.

Sir:—I perceive at page 341 of your *Journal* for November, in an extract from Fairbairn's book on Mills and Mill-work, a reference to Weisbach's formula for finding the head due to the friction of water in pipes when the velocity is known. This formula as given by you, from Mr. Fairbairn, is

$$h_1 = \left(\cdot 01482 + \frac{\cdot 017963}{\sqrt{v}}\right)\frac{l}{d} \times \frac{v^2}{2g}:$$

I beg to say, the correct reduction of Weisbach's formula to English feet measures, is

$$h_1 = \left(\cdot 0144 + \frac{\cdot 01716}{\sqrt{v}}\right)\frac{l}{d} \times \frac{v^2}{2g};$$

and I can speak from experience that it can be depended upon for giving practically correct results. It has, however, for use a very great disadvantage, namely, that it is not possible to solve it directly for v, so as to find the value of the velocity in terms of length, dia-

meter, and fall of the pipe; and as this is what is most generally required, this formula loses much of its value as a practical rule for ready application without tables. It is evident to me that Mr. Neville's general, yet simple formula, page 217, 2d edition of his book,* and

$$v = 140\sqrt{rs} - 11(rs)^{\frac{1}{3}},$$

also as given in your *Journal*, vol. xv., p. 353, in which $s = \frac{h}{c}$ and $r = \frac{d}{4}$, remedies this defect, and the results I have found, for ranges of velocity between 6 inches and 16 feet, in all descriptions of uniform long channels, to be more correct than those found from any other formula I had occasion to calculate from. Mr. Fairbairn must have taken the reduction of Weisbach's formula from vol. i., p. 431, of the English translation of Weisbach's book,† and it differs equally from the reduction by Prof. James Thomson, Belfast, in Weale's Engineer's Pocket-book, and that given by Mr. Neville, p. 213, 2d edition of his valuable book. I have carefully gone over every formula for finding the flow through long uniform channels. Neville's, Weisbach's, and Du Buat's, are unquestionably the best. Young's, Eytelwein's, and Prony's, are only accurate within very limited ranges of velocity, and all others are but modifications of these last, suited to different standards of measurement, and equally limited to their application.

I am, Sir, your obedient servant,

AN OBSERVER.

[It was pointed out in the review above referred to, that Weisbach's formula was repeated at the foot of the tables with rather smaller constants than in the text. Our correspondent gives the formula as it is given under Mr. Fairbairn's tables.—ED. C. E. & A. J.

* Weale, 59 High Holborn, London. † Bailliere, 219 Regent Street, London.

On the Form and Materials for Iron-Plated Ships, and the Points requiring attention in their Construction. By Mr. JOSEPH D'A. SAMUDA.

From the Lond. Mechanics' Magazine, January, 1862.

The author stated that, iron-plated ships having now become a necessity, it was important to ascertain, first, the best description of construction of ship and armor, and secondly, the best form and dimensions of vessel.

To effect these objects, there were four indispensable conditions:—first, these vessels must be of such dimensions and power, and be built on such lines, that they should always command a superiority in speed over the best timber-built frigates afloat; secondly, they must be protected with armor over their entire length; thirdly, the armor must be so applied as to be capable of rapid replacement, or repair; and fourthly, the armor should enter into the construction of the ship, and thus give strength to the whole fabric, as well as protect it from an enemy's fire.

These conditions had only been partially attained in the vessels already constructed, or proposed to be constructed; for the *Warrior* class obtained speed alone, the *Defence* class failed in all, the *Valiant* class only approached the second condition, and the three new ships of 6700 tons burthen, recently contracted for at a cost with their engines of £400,000 each, would probably possess the first and second, but not the third and fourth conditions.

Although the *Warrior* was highly creditable as a first effort, and was not defective in strength, yet it was a complicated and costly construction, and its character should not, therefore, become stereotyped, as incapable of further improvement, or as if it were not desirable to seek for it.

The author proposed that the framework of the hull should be built as in an ordinary first-class steamer of the same size; and that, outside the framework, and riveted to it, there should be five longitudinal ribs, at intervals of 5 feet, reaching 20 feet below the gunwale. These longitudinal ribs should be of bars of rolled iron, $2\frac{1}{2}$ inches in thickness, and 16 inches wide, the outer 4 inches on each side being recessed 1 inch. The ordinary skin plates, 1 inch thick, were then riveted in these recesses, so as to form a flat surface for the reception of the armor, each strake of which was to be made to correspond with the distance from centre to centre of the longitudinal ribs. The edges of the armor plates, 5 inches in thickness, were then to be bolted or riveted through the ribs longitudinally, the vertical butt-joints of each plate, made to break joint with the skin plates, being riveted to corresponding ribs, $2\frac{1}{2}$ inches in thickness, placed between the longitudinal ribs, and attached to them with fish-plates. It had been determined by experiment that this thickness of rib would be sufficient to render the edges of the armor plates, when weakened by the rivet holes, equal in strength to the central body of the plates. By this arrangement, a perfect ship, without armor, was first made; then a complete armor case was attached through the longitudinal ribs, without interfering with the joints, or fastenings of the ordinary skin of the vessel. Indeed, the skin would be so distinct from the armor that, in time of peace, the armor could be removed, and the vessel be used as a transport, if desired. By these means, the armor could be rapidly repaired at any point, and there would be no necessity for tongueing and grooving the plates, adopted as an expedient by the Admiralty to remedy the bending up at the edges, which the present imperfect mode of fastening rendered them liable to.

Thus, protection would be obtained over the entire length of the vessel, by the armor admitting of rapid replacement, and entering into the construction of the ship. It remained only to show what dimensions and power were necessary to secure speed. For a 32-gun frigate, constructed as described, the best dimensions would be 382 feet long, 55 feet beam, and $31\frac{1}{2}$ feet deep to the main deck; 5600 tons burthen, and fitted with engines of 1200 H. P., by which a speed of 15 knots an hour could be obtained, with the armament, ammunition, and coal on board, and with the port sills 9 feet above the water

line. Such a vessel would have even greater speed than the *Warrior*, and be wholly protected over the entire length of the sides.

As the importance of complete protection had now been recognised by the Admiralty, it was desirable to compare this armor-skin vessel, of 5600 tons burthen, with those now building. The Admiralty vessels were to be 6700 tons burthen, and 1250 H. P., but they would not be able to carry a heavier armament, or possess a higher speed than the proposed vessel; they would be less manageable, form larger objects to fire at, and cost £400,000 each instead of £340,000, or, in a fleet of twenty-four such frigates, one million and a half pounds sterling more.

For coast defences, vessels might be built, protected from stem to stern, having a length of 200 feet, beam of $48\frac{1}{2}$ feet, depth of 25 feet, burthen of 2200 tons, and engines of 350 H. P., pierced for thirty-two 68-pounder guns, but carrying only sixteen, with a draft of water of 16 feet, when the guns, ammunition, and coal, were on board, and capable of attaining a speed of 11 knots an hour.

In conclusion, the author thought that the time had arrived, when the Admiralty should see the propriety and the advantage to the public service of abandoning the monopoly of restricting all advance in the construction of mail-clad vessels to plans and systems emanating from themselves; and that it would be far better to trust to the engineering skill of this country, leaving it free to take the initiative in improving this branch of national defence, and the Admiralty only exercising a veto within such limits as experience fitted them to form a judgment upon.

It was announced that the discussion upon Mr. Samuda's paper "On Iron-Plated Ships," which was commenced, would be resumed at the next meeting, Tuesday, February 4th.

Institution of Civil Engineers, Jan. 28th, 1862.

On White Gunpowder. By F. Hudson, Esq.

From the London Chemical News, No. 90.

Having lately prepared different samples of white gunpowder (according to the receipt of Dr. J. J. Pohl, given in the *Chemical News*, July 6) for some military engineering experiments, I have tried the process of separately grinding the materials, viz: chlorate of potash, ferrocyanide of potassium, and cane sugar, and then mixing them; also grinding them together with a little water added, and then dried at a temperature of about 150°. I find that those samples which were prepared moist and then dried, are more easily exploded than those prepared by the dry process. In fact, one sample exploded in an open porcelain dish, by simple friction with a spatula with which one of my assistants was crushing some of the larger pieces. Through the explosion, he was laid up for several weeks, and nearly lost his eyesight. No samples prepared dry are as explosive as those prepared moist, the addition of water causing a more perfect mixture of the particles

of its chemical constituents than can be effected by the dry grinding process. This accounts for the greater danger attending the use of white gunpowder prepared in the moist way.

A cannon loaded with the white powder goes off on the application of a few drops of sulphuric acid (equally as well as with a light applied) to its touch-hole.

This property of the gunpowder may possibly be applied to some advantage in the construction and preparation of bomb-shells for long ranges. The shells would not explode (if filled with the white powder, and containing a glass vessel with sulphuric acid) until they struck the object. No useless explosion of the shell could take place in the air, as is too often the case with the ordinary fusee shell.

Its expansive or explosive force is also twice that of common gunpowder. In all experiments performed with this white gunpowder, care must be taken not to compress it too violently; otherwise accidents may frequently occur. A blow with a hammer upon stone with some of the powder upon it, explodes all samples that I have prepared.

On the Manufacture of Cast Steel, and its Application to Constructive Purposes. By Mr. Henry Bessemer, of London.

From Newton's London Journal, February, 1862.

The mode of manufacturing cast steel, which now forms so important a branch of the Sheffield trade, was discovered in the year 1740 by Mr. Benjamin Huntsman, of Handsworth, near Sheffield, who subsequently established steel works at Attercliffe, where his invention has ever since been successfully carried on. In its early stages many difficulties had, however, to be overcome. Materials for lining the furnaces and for making the crucibles had to be sought for and tested; the peculiar marks of iron most suitable for melting had to be determined on by numerous experimental trials; and such was the difficulty at that time of making crucibles which would stand the excessive heat of melted steel, that for a long period only very highly carbonized or "double converted" steel, which required the lowest temperature, could be successfully melted. The first products of a new manufacture, even while the invention still remains in a partially developed state, but too frequently stamp its subsequent character. Thus Huntsman's cast steel, although it was acknowledged to be a pure homogeneous metal, of great value for certain purposes, was still looked upon as a hard and brittle material of very limited use, not bearing a high temperature without falling to pieces, and quite incapable of being welded: even within the last few years this has been the popular idea of cast steel. Improvements in its manufacture have, however, from time to time been introduced, and steel of a milder and less brittle character has long been made, capable of welding with facility, and working at a high temperature without falling to pieces. Its uses have consequently been greatly extended, and the employment of cast steel for the best cutlery and edge-tools has now become universal; indeed,

the excellent quality of the cast steel at present made in Sheffield for these purposes is scarcely to be surpassed. Of late years several of the most enterprising manufacturers have sought to introduce cast steel for a variety of other purposes besides those for which it was originally employed, and it is now used, in some form or other, in almost every first-class machine. Its employment as a material for founding bells and various other articles in clay moulds, as carried out by Messrs. Naylor and Vickers, and the introduction of a valuable material by Messrs. Howell and Shortridge, under the name of homogeneous metal, are prominent examples of the successful adaptation of cast steel to engineering purposes.

The manufacture of cast steel by Huntsman's process is so extensively practised, and is so well known, that it is unnecessary to do more than to recall to mind that crude pig iron has first to go through all the stages of melting, refining, puddling, hammering, and rolling, in order to produce a bar of malleable iron as nearly pure as the most careful manipulation in charcoal fires can make it. Bar iron, on which so much labor, fuel, and engine power have been expended, thus becomes the raw material of this most expensive manufacture. In order to convert the wrought iron bars into blister steel, they are packed with powdered charcoal in large fire-brick chests, and are exposed to a white heat for several days, the time required for heating and cooling them extending over a period of fifteen to twenty days. When thus converted into blister steel, they are broken into small pieces and sorted, according to the quality of the steel, which sometimes differs even in the same bar. For melting this material, powerful air furnaces are employed, containing two crucibles, into each of which are put about 40 lbs. of the broken blistered steel. In about three hours the pots are removed from the furnaces, and the melted steel is poured into iron moulds, and formed into ingots of cast steel; from $3\frac{1}{2}$ to 4 tons of hard coke being consumed for each ton of metal thus melted. When large masses of steel are required, a great many crucibles must be got ready all at the same moment, and a continuous stream of the melted metal from the several crucibles must be kept up until the ingot is completed, since any cessation of the pouring would entirely spoil it; hence, in proportion to the size of the ingot, are the cost and risk of its production increased. The ordinary manufacture of cast steel is therefore obviously conducted at a great disadvantage. If cast steel is to supersede wrought iron for engineering purposes, it will be necessary to cease employing wrought iron as a raw material for this otherwise most expensive mode of manufacture.

The extremely high temperature requisite to maintain malleable iron in a state of fusion, has, from the earliest period of the history of iron down almost to the present day, rendered its purification in a fluid state practically and commercially impossible. Hence arise all those imperfections to which bar iron is subject, every small piece consisting of numerous granules partially separated from each other by scoria, and every large mass being produced only by piling together small bars, with the inevitable result of increasing the former imperfections;

for no two pieces of iron can be brought to a welding heat without becoming coated with oxide; and when this coating is rendered fluid by welding sand, a fluid silicate of the oxide of iron is formed, covering the entire surface to be united. The heavy blows of the hammer or the pressure of the rolls may, and do, extrude the greater portion of this fluid extraneous matter, but it is never wholly removed from between the welded surfaces, and hence a portion of the cohesive force of the metal is lost at every such junction. When a bar of iron is nicked on one side and bent, the rending open of the pile clearly shows this want of perfect cohesion. Nor is this the only difficulty to be encountered; for in the production of large masses of wrought iron it is necessary to raise the temperature nearly to the fusing point, in order to render each additional piece sufficiently soft and plastic to become united to the bloom. This softening of the iron induces a molecular change in the structure of the metal: its natural tendency to crystallize is so powerfully assisted by the long continuance of the high temperature, that its whole structure undergoes a change; large and well defined crystals are formed almost independently of each other, and cohering so feebly to the other contiguous crystals, as in some cases to separate with as little force as would overcome the cohesion of ordinary cast iron.

In the substitution of cast steel for malleable iron, both these sources of difficulty are escaped; for the mass, whether of one ton or twenty tons weight, may be formed in a fluid state into a single block, wholly free from admixture of scoria, while it is perfectly and equally coherent at every part, and the forging of such a solid block of metal into shape is only the work of a few hours; and as there is no welding of separate pieces, it may be worked under the hammer at a temperature at which no molecular change will take place; the metal being far below its fusing point, and much too solid to undergo that destructive crystallization so common in large masses of wrought iron. Thus the difficulties and uncertainty attending the production of all large masses of wrought iron are wholly avoided in producing equally large masses of cast steel.

But, however desirable in the abstract it may be to employ cast steel as a substitute for malleable iron for engineering purposes, it must not be forgotten that there are several important conditions indispensable to its general use. First, the steel must be able to bear a good white heat without falling to pieces under the hammer, otherwise the process of shaping it will not only be expensive, but the partly-finished forging may be spoiled at any moment by being overheated. Secondly, the steel should be of such a tough character as to admit of being twisted or bent into almost any form in its cold state before fracture takes place, whether the force be applied as a gradual strain or by a sudden impact. Thirdly, it should have a tensile strength at least 50 per cent. greater than that of the best marks of English iron. Fourthly, it must especially be soft enough to turn well in the lathe, to bore easily, and to yield readily to the file and chisel, so as not to enhance its original cost by the difficulty of working it into the requi-

site forms. This last is most commercially and practically an important condition, and one which will in future greatly determine the extent of its use.

These desirable objects are believed by the author to be fully accomplished by his process of converting crude pig iron into cast steel at a single operation, forming the subject of the present paper. This process has now been in daily operation in Sheffield for the last two years at Messrs. John Brown & Co.'s Atlas Steel Works, Sheffield.

The crude pig iron chiefly used in this process has been the hot-blast hæmatite pig smelted with coke, which is melted in a reverberatory furnace, and is then run into a vessel, in which its conversion into steel is to be effected. The converting vessel is made of stout boiler plate, and lined with a powdered silicious stone found in the neighborhood of Sheffield below the coal, and known as "ganister." The rapid destruction of the lining of the converting vessel was one of the great difficulties met with in the early stages of the invention: the excessive temperature generated in the vessel, together with the solvent action of the fluid slags, was found to dissolve the best fire-brick so rapidly, that sometimes as much as two inches thickness would be lost from the lining of the vessel during the thirty minutes required to convert a single charge of iron into steel. The ganister now used, however, is not only much cheaper than fire-bricks, (costing only about 11*s.* per ton in the powdered state,) but it is also very durable. [A portion of the lining of the vessel was shown, which had stood ninety-six consecutive conversions before its removal.] The converting vessel is mounted on bearings which rest on stout iron standards, and by means of the gearing and handle it may be turned into any required position. It has an opening at top for filling and pouring out the metal, and in the bottom of the vessel are inserted seven fire-clay tuyeres, each having seven holes. The blast from the engine is conveyed through one of the bearings of the vessel into the tuyere box, at the bottom of the vessel, and enters the tuyeres at a pressure of about 14 lbs. per square inch, which is more than sufficient to prevent the fluid metal from entering the tuyeres.

Before commencing with the first charge of metal, the interior of the converting vessel is thoroughly heated by coke, with a blast through the tuyeres to urge the fire; when sufficiently heated, it is turned upside down, and all the unburnt coke falls out. The vessel being now turned to nearly a horizontal position, melted pig iron is run in from the furnace by the spout, the vessel being kept in such a position, during the time of filling, that the holes of the tuyeres will be above the surface of the metal. When the proper charge of iron has been run in, the blast is turned on, and the vessel is quickly moved up into a vertical position. The blast now rushes upwards into the fluid metal from each of the 49 holes of the tuyeres, producing a most violent agitation of the whole mass. The silicium, always present in greater or less quantities in pig iron, is first attacked, and unites readily with the oxygen of the air, producing silicic acid; at the same time, a small portion of the iron undergoes oxidation, and hence, a fluid silicate of

the oxide of iron is formed—a little carbon being simultaneously burnt off. The heat is thus gradually increased until nearly the whole of the silicium is oxidized, which generally takes place in about twelve minutes from the commencement of the process. The carbon of the pig iron now begins to unite more freely with the oxygen of the air, producing at first a small flame, which rapidly increases, and in about three minutes from its first appearance a most intense combustion is going on: the metal rises higher and higher in the vessel, sometimes occupying more than double its former space, and in this frothy fluid state, it presents an enormous surface to the action of the air, which unites rapidly with the carbon contained in the crude iron, and produces a most intense combustion, the whole mass being, in fact, a perfect mixture of metal and fire. The carbon is now burnt off so rapidly as to produce a series of harmless explosions, throwing out the fluid slag in great quantities; while the combustion of the gases is so perfect, that a voluminous white flame rushes from the mouth of the vessel, illuminating the whole building, and indicating, to the practised eye, the precise condition of the metal inside. The blowing may thus be left off whenever the number of minutes, from the commencement and appearance of the flame, indicate the required quality of metal. This is the mode preferred in working the process in Sweden. But, at the works in Sheffield, it is preferred to continue blowing the metal beyond this stage, until the flame suddenly drops, which it does just on the approach of the metal to the condition of malleable iron: a small measured quantity of charcoal pig iron, containing a known proportion of carbon, is then added, and thus steel is produced of any desired degree of carburation; the process having occupied about twenty-eight minutes altogether from the commencement. The converting vessel is tipped forwards and the blast shut off for adding this small charge of pig iron; after which, the blast is turned on again for a few seconds.

The spout of the vessel is then depressed, and the fluid steel is run into the casting ladle, which is carried by a hydraulic crane, it being counterbalanced by a weight on the opposite end of the jib. When all the metal is poured out of the converting vessel, the crane is raised by water pressure and turned round, for the purpose of running the steel into the ingot moulds. Instead of tilting the casting ladle for pouring into the moulds, it is made with a hole in the bottom, fitted with a fireclay seating, and closed by a plug of fireclay forming a conical valve. The valve rod is coated with loam and bent over at the top, and works in guides on the outside of the ladle, with a handle for opening and closing the valve. By thus tapping the metal from below, no scoria or other floating impurities are allowed to run into the mould, and the stream of fluid steel is dropped straight down the centre of the mould right to the bottom, without coming in contact with the sides of the mould. The moulds are made of a slightly tapered form, so that as the ingot contracts in cooling, it liberates itself from the mould completely on all sides; and the mould is removed by being

lifted off the ingot when sufficiently set. The moulds are arranged in the moulding pit in an arc of the circle described by the casting ladle.

By this process from one to ten tons of crude iron may be converted into cast steel in thirty minutes, without employing any fuel except that required for melting the pig iron, and for the preliminary heating of the converting vessel; the process being effected entirely without manipulation. The loss on the weight of crude iron is from 14 to 18 per cent. with English iron worked in small quantities; but the result of working with a purer iron in Sweden has been carefully noted for two consecutive weeks, and the loss on the weight of fluid iron, tapped from the blast furnace, was ascertained to be only 8¾ per cent. The largest sized apparatus at present erected is that in use at the Atlas Steel Works, Sheffield, the converting vessel being capable of receiving four tons at a time, which it converts into cast steel in 28 minutes. In consequence of the increased size of the converting vessel, in this case, no metal is thrown out during conversion, and the loss of weight has fallen as low as 10 per cent., including the loss in melting the pig iron in the reverberatory furnace.

Specimens of this manufacture, as carried on at the author's works in Sheffield, were exhibited, consisting of a piece of the pig iron employed, which is No. 1 hot-blast hæmatite made with coke; also, a portion of an ingot of very mild cast steel, broken under the hammer to show the purity and soundness of the metal in its cast unhammered state; and an ingot, partly forged, to show how little work with the hammer will produce a forging from these solid blooms of steel. There were also two pieces of steel of the quality employed for making piston rods, which had been bent cold under a heavy steam hammer to show the toughness of the metal: it required very much more force to bend it than would be required to bend wrought iron, but, notwithstanding this additional rigidity, it will yield to any extent without snapping. The tensile strength of this soft and easily wrought metal is as much as forty tons per square inch, or from 15 to 18 tons greater than that of best Yorkshire iron. In turning, planing, boring, and tapping, it will be found that the uniformity of its quality will be less trying to the cutting tools than the hard reeds and sand cracks met with in the common qualities of malleable iron. The above tensile strength of the piston rod steel, however, is by no means the maximum, but, on the contrary, is nearly the minimum strength of the steel converted by this process; but, at the same time, it possesses nearly a maximum degree of toughness; for every additional ton in tensile strength, obtained by the addition of carbon, hardens the steel for working, renders it more difficult to forge, and brings it nearer to that undesirable state when a sudden blow snaps it like a piece of cast iron.

From tables compiled from experiments made at the Woolwich Arsenal, it appeared that after hammering or rolling, the steel or highly carbonized metal exhibits a mean tensile strength of 68 tons per square inch, but from its hardness and unyielding nature, it is totally unfit for many purposes; while the iron or entirely decarbonized metal is so soft and copper-like in its texture as to yield to a mean tensile

strain of 32 tons per square inch, a point unnecessarily low, except in cases where a metal approaching copper in softness is required. The soft, easy working, tough metal, of the quality used for piston rods, is therefore believed by the author to be the most appropriate material for general purposes; while the hard steels that range up to a tensile strain of 50 or 60 tons per square inch should be avoided as altogether too expensive to work, and too dangerous to be employed in any case where sudden strains may be brought upon them.

With reference to the employment of the mild cast steel for constructive purposes, there are few applications of more importance than that which has recently and successfully been made to the construction of steam boilers. The Cornish boiler, as improved by Mr. Adamson, of Hyde, near Manchester, has a large flue tube constructed with narrow plates more than 12 feet long, extending round the flue in one length, and flanched at each edge in a manner which, while it adds greatly to the stability of the flue, demands such qualities in the material employed for its manufacture as are completely found only in metal that has undergone fusion, and has become perfectly homogeneous throughout. A practical illustration of the excellence of this mode of constructing boilers and the powerful strains which the new steel is capable of sustaining safely, is afforded by the steam boilers employed for some time past at Messrs. Platt's works at Oldham, where six of these boilers are in daily use; they are 30 ft. long and $6\frac{1}{2}$ ft. diameter, and the flue is 4 ft. diameter; the plates are $\frac{5}{16}$-inch thick, and the working pressure 100 lbs. per square inch.

The advantages of cast steel are still more marked in the construction of the fire-boxes of locomotive engines. The difficulty of flanching and shaping this work in plate iron without splitting the metal at some part, is so great as to have rendered the employment of copper necessary hitherto for this purpose; but the shape required can now be obtained with ease and certainty by hammering up a sheet of metal rolled from one of the cast ingots, such as that now exhibited. One of these fire-box plates, flanched by Mr. Anderson, is also shown, and clearly illustrates the facility with which the new metal may, under skilful hands, be wrought into any required form. The perfect continuity of the material and its entire freedom from joinings or weldings also obviously render it specially suitable for the tube plates of locomotive engines; for, however near the holes are made to one another, there is no danger of their having a flaw or other weak place between them. Nor is it in the construction of the boiler alone that the cast steel may be employed with advantage in locomotives: the axles, whether plain or cranked, the piston rods and guide bars, and last, but not least, the wheel tyres, are all exposed to so much abrasion, and to such sudden and powerful strains, that a tough strong material capable of withstanding this destructive wear and tear, is imperatively demanded for the satisfactory construction and economical working of the engine.

The special aim of the author during the first year of his labors, and which throughout the last six years has never been lost sight of, was

the production of a malleable metal peculiarly suitable for the manufacture of ordnance. By means of the process that has been described, solid blocks of malleable cast steel may be made of any required size, from 1 to 20 or 30 tons weight, with a degree of rapidity and cheapness previously unknown. The metal can also, with the utmost facility, be made of any amount of carburation and tensile strength that may be found most desirable. Commencing at the top of the scale with a quality of steel that is too hard to bore, and too brittle to use for ordnance, it can with ease and certainty be made to pass from that degree of hardness, by almost imperceptible gradations downwards, towards malleable iron; becoming at every stage of decarburation more easy to work and more and more tough and pliable, until it becomes at last pure decarbonized iron, possessing a copper-like degree of toughness not found in any iron produced by puddling. Between these extremes of temper the metal most suitable for ordnance must be found; and all qualities are equally cheap and easy of production.

From the practice now acquired in forging cast steel ordnance at the author's works in Sheffield, it has been found that the most satisfactory results are obtained with metal of the same soft description as that employed for making piston rods. With this degree of toughness the bursting of the gun becomes almost impossible; its power of resisting a tensile strain being at least fifteen tons per square inch greater than that of the best English bar iron. Every gun, before leaving the works, has a piece cut off the end, which is roughly forged into a bar of 2 inches by 3 inches section, and bent cold under the hammer, in order to show the state of the metal after forging. Several test bars cut from the ends of guns recently forged were exhibited.

The power of this metal to resist a sudden and powerful strain was well illustrated by a piece of a gun muzzle, which was one of several tubular pieces that were subjected to a sudden crushing force at the Royal Arsenal, Woolwich, under the direction of Col. Wilmot. The pieces were laid on the anvil block in a perfectly cold state, and were crushed flat by the falling of the steam hammer, but none of them exhibited any signs of fracture when so tested. Probably the best proof of the power of the metal to resist a sudden violent strain was afforded by some experiments made at Liège by order of the Belgian government, who had one of these guns bored for a 12 lbs. spherical shot of $4\frac{3}{4}$ inches diameter, and made so thin as to weigh only $9\frac{1}{4}$ cwts. This gun was fired with increasing charges of powder and an additional shot after each three discharges, until it reached a maximum of $6\frac{3}{4}$ lbs. of powder and eight shots of 12 lbs. each or 96 lbs. of shot, the shots being thus equal to about one-tenth of the weight of the gun. It stood this heavy charge twice, and then gave way about 40 inches from the muzzle, probably owing to the jamming of the shots. The employment of guns so excessively light, and charges so extremely heavy, would of course never be attempted in practice.

Some idea of the facility of this mode of making cast steel ordnance is afforded by the time occupied in the fabrication of an 18-pounder gun exhibited to the meeting. The melted pig iron was tapped from

the reverberatory furnace at 11·20 A. M., and converted into cast steel in 30 minutes; the ingot was cast in an iron mould 16 inches square by 4 feet long, and was forged while still hot from the casting operation. By this mode of treating the ingots, their central parts are sufficiently soft to receive the full effect of the hammer. At 7 P. M., the forging was completed, and the gun ready for the boring mill.

The erection of the necessary apparatus for the production of steel by this process, on a scale capable of converting from crude iron enough steel to make 40 of such gun blocks per day, will not exceed a cost of £5000, including the blast engine; hence the author cannot but feel that his labors in this direction have been crowned with entire success: the great rapidity of production, the cheapness of the material, and its strength and durability, all adapt it for the construction of every species of ordnance.

Proceedings Insti. Mech. Engineers, July 31, 1861.

Extraction of Butter. By M. J. A. Barrad.

The time required for the formation of butter varies very much with the temperature. Near 54° Fahr., it requires ten times longer than at 68°. But when the temperature is too high, the yield of butter is much diminished. The best temperature for getting butter from milk is between 60 and 68°. The losses are much less when cream is churned in place of milk. The best temperature for getting the most butter from cream, and in the least time, too, is between 57 and 61°.

Cosmos.

Improvements in the Preparation of a Coloring Matter for Dyeing Textile Materials and Fabrics, and other Substances.—Patent of John Dale.

From the London Chemical News, No. 54.

This patent appears to us to be both chemically and commercially important. The principle involved is simple enough, and merely consists in extracting the coloring matters of the dye-woods with alkaline solutions, and re-precipitating by means of acids. The coloring matters of barwood, camwood, redwood, &c., are, as is well known, soluble in alkalies, and the alkaline solutions are of a much darker and more intense color than the mere aqueous infusions. The alkaline solutions are, however, destitute of dyeing properties, and, moreover, any excess of alkali causes the coloring matter to undergo a chemical metamorphosis sufficient to permanently deprive it of tinctorial power. But by regulating the strength of the alkaline solution used as a solvent, the color may be extracted in its red condition, and free from the peculiar purple tint so familiar to all who have used logwood as the test in Dr. Price's improvement of Peligot's modification of Will's process for determining nitrogen. The patentee uses pressure in extracting, and pumps the boiling alkaline solution through the woods. 120 lbs.

of caustic alkali of 25 per cent., require 500 to 800 gallons of water for dilution before being sufficiently weak to prevent injury to the coloring matter. The patentee does not state from what weight of the different woods the above amount of fluid is capable of extracting the color. That the quantities vary greatly with the nature of the wood is, however, plain. The patentee states that camwood contains more acid than the other wood, and, consequently, requires more alkali.

On the Filtration of Air.

From the Lond. Edin. and Dub. Phil. Mag., May, 1861.

As the result of a lengthened investigation on filtration of the air in reference to fermentation, putrefaction, and crystallization, Schrœder* is led to the following conclusions:—

1. A vegetable or animal can only be formed from having vegetable or animal organisms. *Omne vivum ex vivo.*

2. There is a series of phenomena of fermentation and putrefaction which arise solely from microscopic germs furnished by the atmosphere. These are more especially the formation of mould, of wine-yeast, of the lactic acid ferment, of the ferment which produces the decomposition of urine.

3. Vegetable or animal substances, boiled and closed while hot by means of cotton, remain in that condition quite protected against every kind of fermentation, putrefaction, or formation of mould, if all the germs in them capable of development are destroyed by boiling; for the germs which might reach them from the air are filtered out by the cotton.

4. The germs of most vegetable or animal substances are completely destroyed by simple boiling. A boiling for a short time at 100°C. is also sufficient to kill all germs furnished by the air.

5. But milk, the yellow of egg, and meat, contain germs which are not completely destroyed by a short boiling at 100°. But boiling at a higher temperature under a pressure of two atmospheres in the digestor, or long-continued boiling at 100°, is sufficient to kill even these germs.

6. The germs of milk, yellow of egg, and of meat, even when they have been submitted to a boiling at 100°, not continued, however, too long, are capable of developing themselves as a specific putrefaction ferment, and not unfrequently, at least in the yolk of egg, in the form of long but inert fibrils.

7. This specific putrefying ferment is of animal nature. It develops and increases at the expense of albuminous substances. It is, however, incapable of increase under conditions which are all that are necessary to vegetable formations.

8. The crystallization of supersaturated solutions is commenced or induced by the action of the surface of solid bodies.

9. The induction necessary to set up the crystallization of the soluble hydrates from a supersaturated solution, is less than that necessary for the crystallization of the more difficultly soluble hydrates.

* Liebig's Annalen, March, 1861.

10. The surface of a crystal of the same nature exercises the strongest inducing action. Next to that comes the layer of air which forms on the surface of solid bodies. These coatings are destroyed by heating, continued wetting, or by cleaning, and are only formed slowly again in filtered air.

11. The crystallization of the more soluble hydrates from supersaturated solutions, which is set up even by a feeble induction, only experiences a feeble induction on the surface of the crystal of the same kind, and hence only progresses very slowly.

12. Supersaturated solutions closed with cotton, keep for a long time unchanged, because the cotton filters all the solid particles from the air which gains access. Agitation has no action on the crystallization; it only induces it if supersaturated solutions are in contact with such places of the surface as are fitted to induce the crystallization.

Improvements in the Production of Colors for Dyeing or Printing. (A communication from L. and E. Boilley Frères, of Paris.) JOHN HENRY JOHNSON.

From the London Chemical News, No. 54.

This invention, which appears to us of great value, is for producing from indigo what the inventors term "purple blue." They prepare it from indigo by acting on it with—1. Bisulphate of soda; 2. A mixture of ordinary sulphuric acid with anhydrous phosphoric acid; 3. A mixture of sulphuric acid and chloride of potassium. The first appears to be the best process: it is conducted as follows:—One part of finely powdered and sifted indigo is gradually added, with constant stirring, to from ten to twenty times its weight of anhydrous bisulphate of soda, in a state of fusion at a temperature of from 200° to 300° C. (=392° to 572° F.) [Berzelius recommends preparing the bisulphate of soda by heating 10 parts of dry sulphate of soda with 7 parts of monohydrated sulphuric acid, the temperature of fusion being kept up until the mixture flows quietly at a red heat.—ED.] The fusion of the indigo with the acid salt is continued until the mixture colors water a violet red. The mass is then thrown into water (7 or 8 gallons to each pound of mixture), and well stirred. [Surely the solution should be filtered before proceeding to the next stage.] Two pounds of common salt are now added to the solution for every pound of mixture employed; and, as the solution cools, the color is precipitated in an impure state. This "purple blue" only requires to be well washed to render it sufficiently pure for use. As it is soluble in water, a saline solution must be used for washing. The patentee recommends solutions either of common salt, chloride of potassium, or acetate of potash, for this purpose. "It only remains to filter the liquid in order to collect the precipitate, and to dry the same after having removed the matters which are found on the surface. These matters, which are of a blackish or greenish color, are of another nature, and being of a lighter weight, they will not be deposited until the liquid has been allowed to stand some time. The product thus obtained is in the form of small crystals." Does the patentee mean that the impurity, or the

"purple blue," is crystalline? As it stands in the patent, it would appear to be the impurity. The patentee does not give the slightest information as to the method of employing the color in dyeing or printing. It is probably used in the same way as "carmine of indigo."

Writing Ink.

To the Editor of the *Chemical News*:—

Sir: M. de Champour and M. F. Malepeyre, in their Manual, say that Ribaucourt's ink is one of the best at present in use. The formula for its preparation, which may interest some of your readers, is as follows:—

Aleppo galls, in coarse powder, .	8 ounces.
Logwood chips, . .	4 "
Sulphate of iron, . .	4 "
Powdered gum-arabic, . .	3 "
Sulphate of copper, . .	1 "
Crystallized sugar, . .	1 "

Boil the galls and logwood together in 12 lbs. of water for an hour, or till half the water has been evaporated; strain the decoction through a hair-sieve, and add the other ingredients; stir till the whole, especially the gum, be dissolved; and then leave at rest for 24 hours, when the ink is to be poured off into glass bottles and carefully corked. I am, &c.,

A Country Subscriber.

[A Correspondent, Mr. J. Horsley, has favored us with the following receipt for a good chemical writing fluid:—Triturate in a mortar 36 grains of gallic acid with $3\frac{1}{2}$ ounces of strong decoction of logwood, put it into an 8-ounce bottle, together with 1 ounce of strong ammonia. Next dissolve 1 ounce of sulphate of iron in half an ounce of distilled water by the aid of heat; mix the solutions together by a few minutes agitation, when a good ink will be formed, perfectly clear, which will keep good any length of time without depositing, thickening, or growing mouldy, which latter quality is a great desideratum, as ink undergoing that change becomes worthless. It will not do to mix with ordinary ink, nor must greasy paper be used for writing on with it.—Ed. C. N.]

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, February 20, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from J. K. Whillden, Esq., of Washington, D.C.

Donations to the Library were received from the Statistical Society, and the Society of Arts, London; J. K. Whillden, Esq., Washington City, and Charles Ellet, Jr., Esq., Georgetown, D. C.; Daniel Tredwell, Esq., Cambridge, Mass.; George R. Smith, Esq., Penna. Senate,

Harrisburg, Penna.; H. P. M. Birkinbine, Esq., John W. Nystrom, Esq., Prof. John F. Frazer, and the Mine Hill and Schuylkill Haven Railroad Company, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of January was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (2) were proposed, and the candidates proposed at the last meeting (10) were duly elected.

The Board of Managers reported that they had organized for the present year by electing Washington Jones Chairman, and Messrs. Isaac S. Williams and Wm. A. Drown, Curators, and have appointed the following Standing Committees:—

On Publications.	*On Instruction.*	*Managers Sinking Fund and Finance.*
John C. Cresson,	John F. Frazer,	Frederick Fraley,
B. H. Bartol,	Frederick Fraley,	Samuel V. Merrick,
J. Vaughan Merrick,	Isaac B. Garrigues,	Evans Rogers,
Fairman Rogers,	Alan Wood,	John F. Frazer,
Washington Jones.	George Erety.	George Erety.

The Standing Committees for the ensuing year were appointed by the President, and approved as follows:—

On the Library.	*On Cabinet of Models.*	*On Cabinet of Minerals.*
John Allen,	James Agnew,	Isaac H. Conrad,
Henry Ames,	Wm. B. Bement,	John F. Frazer,
James H. Cresson,	Jos. B. Cooper,	Emile Geyelin,
Geo. M. Conarroe,	James Fraiser,	Isaac B. Garrigues,
George Erety,	H. Hockstrasser,	Henry Hartshorne,
John Ferguson,	John Kile,	John L. LeConte,
Jas. H. Gordon,	F. W. Leaming,	B. Howard Rand,
Raper Hoskins,	Thos. H. McCollin,	R. E. Rogers,
Jas. T. Lukens,	John L. Perkins,	Percival Roberts,
G. L. Martindale.	Coleman Sellers.	J. C. Trautwine.

On Cab. of Arts & Manuf.	*On Exhibitions.*	*On Meetings.*
Daniel Allen,	John E. Addicks,	Wm. H. Brown,
Jas. C. Booth,	John Agnew,	Charles S. Close,
Thos. Bickerton,	Jas. H. Bryson,	D. P. Dieterich,
Henry Bower,	Jas. H. Cresson,	James Dougherty,
R. C. Cornelius,	Wm. A. Drown,	P. G. Eastwick,
C. G. Crane,	John M. Gries,	Robert H. Gratz,
Chas. E. Foster,	Edward Greble,	Henry Howson,
D. M. Hogan,	Wm. Harris,	Washington Jones,
Samuel Sartain,	T. S. Stewart,	Edward Longstreth,
Chas. A. Sharpe.	Isaac S. Williams.	John E. Wootten.

On Meteorology.

Chas. T. Adams,	James A. Meigs,
Chas. M. Cresson,	B. V. Marsh,
T. M. Drysdale,	Fairman Rogers,
John F. Frazer,	James S. Whitney,
Jas. A. Kirkpatrick,	Thomas J. Weygandt.

Mr. Howson exhibited a large model of a Cannon invented by the late Archillius Lawrence, to whose executors a patent has recently been allowed.

The cannon is an improvement on the celebrated Armstrong gun, and is arranged for loading at the breech through a hollow screw, which, when tight, confines a sliding gate against the rear of the barrel.

The gate is so hung to an operating lever as to be rendered self-adjusting, both to the end of the screw and rear of the barrel, and the lever is so connected to a slotted cam on the hollow screw, that by moving this cam in one direction, the screw may be loosened, and the gate at the same time depressed, preparatory to the insertion of the charge; and on moving the cam in the opposite direction, the gate is first raised, and then tightened by the screw.

The cannon has been especially designed with the view of obtaining a perfectly gas-tight packing at the breech.

Mr. Howson also exhibited some remnants of a rifle barrel, to illustrate the results of a recent dangerous experiment.

The barrel was about three-eighths of an inch bore, and the metal over a quarter of an inch thick. The barrel was filled with cartridges, each cartridge consisting of a ball with a charge of powder, and each ball having a hole through it for the reception of a fuse.

The supposition was, that after igniting the powder of the first cartridge, a short time would elapse before the explosion of the second, and so on.

On igniting the first cartridge, however, the whole exploded, and the barrel was rent into a number of pieces, the experimenters narrowly escaping serious injury.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.

January.—The average temperature of the month of January, 1862, was a little less than one degree above the average temperature of the month for eleven years.

The warmest day of the month was the 1st, of which the mean temperature was 43·8°. The highest degree of heat (54°) was reached on the same day.

The coldest day was the 5th, with a mean temperature of 18·8°. The lowest degree (10°) was reached on the morning of the same day.

The range of temperature for the month was, consequently, 44°.

The temperature was below the freezing point on 22 days of the month, though it rose above that point in the course of the afternoon of every day except five, namely, the 3d to the 6th inclusive, and the

14th. The cold weather during the first week of the month filled the Delaware River with large pieces of floating ice; and the Schuylkill was frozen so tightly as to allow of skating, almost anywhere above the dam. After the 8th, the weather became warm and rainy, and rain or snow fell almost every day until the 22d. From the 15th until the end of the month, the mean temperature was remarkably steady, the lowest being 29° and the highest 36·3°.

The greatest change of temperature in the course of one day was 22°, on the 1st day of the month; the least was 2°, on the 21st. The average daily oscillation of temperature for the month (10·21°) was 1½° below the average oscillation for the month of January, and was less than occurred in that month since the year 1855, when it was but 9·4°.

The greatest mean daily range of temperature was 14·2°, and occurred between the 1st and 2d days of the month; the least was 1·3°, and occurred twice, between the 22d and 23d, and between the 29th and 30th. The average daily range for the month (5·04°) was nearly 1° less than that for January, 1861, and 1½° less than the average range for eleven years. This was the smallest mean daily range observed in any January during the eleven years of observation. The nearest approach to it was 5·5°, in January, 1853.

The pressure of the atmosphere was greatest on the 14th of the month, when the height corrected for temperature was 30·408 inches. The greatest average pressure for a day was 30·404 inches, on the 14th. The pressure was least (29·325 ins.) on the afternoon of the 1st; the average pressure for the day was 29·472 inches. The average pressure for the month (29·922 ins.) was five-hundredths of an inch less than for January, 1861, and nearly four-hundredths of an inch less than the average pressure for January for eleven years.

The greatest mean daily range of atmospheric pressure was 0·594 of an inch, and occurred between the 14th and 15th days of the month; the least was 0·017 of an inch, between the 22d and 23d. The average mean daily range for the month (0·261 in.) was the greatest observed in any January during the eleven years of observation; the nearest approach to it was 0·249 inches in January, 1854. It was three-hundredths of an inch greater than for January of last year, and nearly five-hundredths of an inch greater than the average range for the month for eleven years.

The force of vapor, dew point, and relative humidity were all less than usual. The greatest variation from the average was at 2 P. M.; while at 7 A. M. they were very near the average for the whole period of observation. The force of vapor was greatest (0·275 in.) on the evening of the 12th, and least (0·051 in.) on the evening of the 4th. The average for the month was four-thousandths of an inch below the general average.

The relative humidity was greatest (100 per cent., the atmosphere being completely saturated with moisture,) on the evening of the 29th, during the prevalence of a heavy fog and a drizzling rain. It was

least (32 per cent.) on the afternoon of the 26th of the month. The average for the month was 2 per cent. below the average for January of last year, but less than the half of 1 per cent. below the general average.

Rain or snow fell on sixteen days of the month, to the aggregate depth of 4½ inches. Of this amount, more than one inch fell between 6 P. M. of the 24th, and 3 P. M. of the 25th. The number of rainy days was greater than ever before observed in the month of January, the nearest approach to it being 13 days in January, 1861. The amount of rain that fell was but an inch and a quarter more than the average amount for eleven years, though it was nearly an eighth of an inch less than the quantity that fell in the same month last year.

There was but one day of the month, the 26th, entirely clear or free from clouds at the hours of observation, though the 2d and the 3d were covered, on the average, but three and seven-tenths respectively. The sky was completely covered with clouds at those hours on fourteen days of the month. The average amount of sky covered with clouds during the month of January, 1862, was about 74 per cent.; during January, 1861, it was 60 per cent., and the average amount for eleven years is but 58 per cent. of the hemisphere.

A Comparison of some of the Meteorological Phenomena of JANUARY, 1862, *with those of* JANUARY, 1861, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Jan. 1862.	Jan. 1861.	Jan. 11 years.
Thermometer.—Highest, . .	54°	49·5°	62·0°
" Lowest, . .	10	1·0	— 5·5
" Daily oscillation,	10·21	11·61	11·68
" Mean daily range,	5·04	5·98	6·62
" Means at 7 A. M.,	29·36	27·67	27·48
" " 2 P. M.,	34·47	34·34	35·04
" " 9 P. M.,	31·97	30·90	30·92
" " for the month,	31·93	30·97	31·14
Barometer.—Highest, . .	30·408 in.	30·526 in	30·704 in.
" Lowest, ...	29·325	29·460	28·911
" Mean daily range, .	·261	·229	·213
" Means at 7 A. M., .	29·942	29·991	29·976
" " 2 P. M., .	29·894	29·953	29 937
" " 9 P. M., .	29·931	29·968	29·962
" " for the month,	20·922	29·971	29·958
Force of Vapor.—Means at 7 A. M.,	·134 in.	·128 in.	·133 in.
" " " 2 P. M.,	·145	·144	·152
" " " 9 P. M.,	·142	·145	·145
" " " for the month,	·140	·139	·144
Relative Humidity.—Means at 7 A. M.,	80·0 per ct.	80 4 per ct.	80·4 per ct.
" " " 2 P. M.,	70·7	71·8	69·3
" " " 9 P. M.,	75·4	80·7	77·2
" " " for the month,	75.4	77·7	75·7
Rain and melted snow, amount	4·500 in.	4·620 in.	3·229 in.
No. of days on which rain or snow fell,	16·	13	10·5
Prevailing winds—Times in 1000-ths,	N 18°26′ W ·335	N 52°12′ W ·375	N 60°2′ W ·333

JOURNAL

OF

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

APRIL, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Memoranda on Electric Lights. By J. K. Whilldin, Civ. Eng.

In the autumn of 1861, Prof. Way visited this country, and made several exhibitions of his electric light. The varieties of apparatus which he has employed, display much skill and ingenuity.

During the Professor's sojourn in Washington, the attention of the Lighthouse Board was directed to this light, and, through the instrumentality of Prof. Joseph Henry, and the energetic Secretary of the Board, Commander T. A. Jenkins, U. S. N., arrangements were made to exhibit it from Fort Washington, which can be seen from the Presidential mansion, and is distant in a direct line about 13 miles.

Accordingly, on Monday, Sept. 23, a small party, which the writer had the pleasure to accompany, left the Navy Yard in the steam-tug *Pusey*, and were landed at the Fort a little before sundown.

A Fresnel lens, of the 4th order, had been loaned for this occasion by Secretary Jenkins; it was placed on the parapet of the Fort, the apparatus adjusted to it, the battery filled, the mercury poured in the reservoirs, and in the course of a couple of hours everything was in readiness for a display of the light.

By previous agreement at Washington, certain signals, represented by numbers, were to be made to the President, who witnessed the light from the "White House." A rapid succession of flashes indicated when a signal was about to be made; then, if 23, for instance, was the number of such signal, there would be given, first, two dis-

tinct flashes; then a pause, say of half a minute, and again, three distinct flashes.

A large number thus made were sent during the evening, all of which were clearly seen and interpreted. The experiment continued about three hours, when our party returned to Washington.

Owing to the limited time for preparation, the arrangements in this instance were necessarily imperfect, and did not do justice to the skill of Prof. Way. It was not certain that the lens was quite level, or that the light was quite in the focus, and thus, owing to the small bulk of flame and consequent small divergence of the rays, it is probable that much light was either thrown above or below the horizon.

But, inasmuch as all essential features were embodied in the apparatus employed, it is hoped that a slight sketch may not be devoid of interest at a time when so much attention is being directed to superior modes of illumination.

The battery consisted of about 45 Bunsen elements (solid carbon as obtained from gas-retorts, and amalgamated cast zinc, nitric acid being the exciting agent). The cost of maintenance per hour is stated by Prof. Way to be about 38 cents; but this, he believes, may be reduced one-half by recovering the nitric acid and utilizing the product.

A noticeable objection to this form of battery is the abundance of nitrous fumes generated, which are very stifling, and would render indoor operations hazardous, if not impossible.

Prof. Way states that the magneto-electric machine, generating current electricity, will answer equally well for the mercury light.

It would, no doubt, in the majority of cases be substituted for a battery, although it would render necessary a steam engine or other power. Here is a case where a small economical motor, like Ericsson's hot air engine, might be advantageously introduced. One requiring no specially skilled labor, dispensing with such dangerous adjuncts as steam boilers, and independent of a water supply—not always to be had when most wanted.

Plate I., Fig. 1, is an elevation, partly in section, of the lens and apparatus as used at the Fort. Fig. 2 is an enlarged section of the parts immediately around the light. Fig. 3 is a plan of the lower part of Fig. 2, and shows how the flanch of the cylinder C is secured to the plate K. Fig. 1 is drawn about one-tenth of real size. Figs. 2 and 3 are quarter size.

The mercury is first poured into the upper cast iron reservoir A (Pl. I. Fig. 1), whence it issues through the wrought iron tube E, and is conducted immediately over the glass cylinder C, where the light is exhibited. The pipe E is connected with the parts below it by means of a short piece of gutta-percha tube; this arrangement permits the removal of the glass cylinder and attachments, the adjustment of the movable tube D, and also affords a convenient mode of stopping the flow of the mercury when desired.

The latter is effected by a steel clasp L, which compresses the tube tightly, but is removed when the light is in operation.

The sliding tube D, which enters the cylinder C, is made of steel, smoothly finished; it has a rack on one side, into which a small pinion gears, whereby the tube may be raised or lowered. At the lower end, there is an orifice not larger than a fine sewing needle; through this the mercury flows, in a stream resembling a thread of silver, into the small cup H beneath; said cup being of wrought iron, with its stem screwed into the cast iron plate K. The light is produced between the tube D and cup H, by the electricity traversing the slender thread of mercury, which it does when the wires M and N are connected with the battery to complete the circuit.

The cylinder enclosing the light is one piece of glass, both ends being cemented in brass flanches with red lead. The lower flanch and the plate K are carefully faced, so as to form an air-tight joint. All parts of the cylinder and attachments are made so as to completely prevent the escape of mercurial vapor into the outer air.

The mercury overflowing the cup H, passes into the lower cast iron reservoir B, by means of a wrought iron tube F, whence it may from time to time be drawn off, and returned to the upper reservoir A. The insulation of the reservoirs and attachments is effected simply by the wooden box shown in Pl. I, Fig. 1.

It is important to notice that, in the production of the light, the mercury is *not consumed*, but it may be used over and over again without any apparent deterioration or loss.

The *intensity* of the light varies with the battery power, it being a maximum some time after the battery is filled, and becoming weakened towards the close, as the acids become saturated.

The electricity dashes the mercury against the side of the cylinder C, and, after a time, patches resembling the coating of ordinary mirrors, adhere to the glass; these, being opaque, injure to some extent the efficiency of the light; but, as new cylinders can be readily exchanged for such as become coated, it is not believed that this is a serious difficulty. During the three hours the light was exhibited at Fort Washington, no deposit was found on the glass.

The capability that Prof. Way's light possesses, of being instantaneously lighted and extinguished, and in any order we please, renders it not only very valuable for military purposes in signalling, but also promises to solve an important problem in lighthouse engineering, viz: so to distinguish a given lighthouse from every other on a coast, as to enable the mariner approaching and seeing the light to determine his position, and thereby reduce the difficulty and avoid the dangers incurred in making a harbor.

By means of clock-work arranged by Prof. Way, the circuits are broken in any given order, producing corresponding occultations of the light; and a lighthouse may thus have a particular number given to it, indicative of its character and position; this number may be repeated at short intervals throughout the night.

The mode of distinguishing lights by occultation was proposed some years ago by Babbage, but not executed, owing, perhaps, to the difficulty of applying such a system to the present arrangement of opti-

cal apparatus. The flashing lights produced by the Fresnel lenses are the nearest approach to such a system that has yet obtained any considerable currency.

There is a great saving in bulk and cost of lens apparatus with the electric light. This will be the more apparent when we remember that our first order lenses, such as those at Capes May, Henlopen, Hatteras, &c., are about 6 feet diameter, and 9 feet high, and are obtained from Mons. Lepaute or Messrs. Sautter & Co., of Paris, at a price varying from $5000 to $11,000.

In the place of these, apparatus not exceeding in cost $400 or $500 might be readily substituted; indeed, Prof. Faraday states that all the light from an electric lamp might be utilized in a space not exceeding the size of an ordinary hat, reducing the cost yet more. It is well known that, with our present system, with oil lamps, we have but one method of increasing the *quantity* of light, that is, by increasing the number of burners, and thereby necessarily increasing the bulk of the flame; in a first order lamp, for instance, there are four concentric wicks, the outer one being about 3¾ inches diameter; this bulk of flame renders it exceeding difficult to utilize the light, for if the prisms are true for one point or focus, they will not be so for other points in the luminous mass, and it becomes necessary that the lens be large in order that the flame may be relatively small.

But with the electric lamp, any amount of light may be accumulated *in the focus*, by increasing the amount of electricity, which, of course, involves a corresponding increase in cost.

Prof. Holmes' magneto-electric light, with carbon points, has been on trial for six months in the South Foreland lighthouse, England, and, from the evidence given in a late Parliamentary report (1861), it would seem to have been eminently successful.

In France, also, a somewhat similar arrangement has been successfully employed, the magneto-electric machine being slightly different, the currents in the English machine being in one direction, while those in the French machine alternate. No practical difference between the two lights has been detected.

Prof. Faraday compared the intensity of the electric light with that of the sun, by means of dark glass; they were about equal, but the sun was not at its brightest. In relation to the South Foreland light, he says:—"The eyes of the keepers are not affected, though the blue glasses provided for them are very pale in color, for the light is better watched by observing the *place* and *intensity* of the rays which fall here and there on the walls of the lantern, than by looking at the light itself."

In France, experiments made by Mons. Reynaud and others, show the comparative intensities of various lights, as follows:—

Argand burner, . . .	1.
First order flash, . . .	80 to 90.
Electric light, . . .	94.
" cast glass flash, .	55,000.
" first order flash, .	220,000.

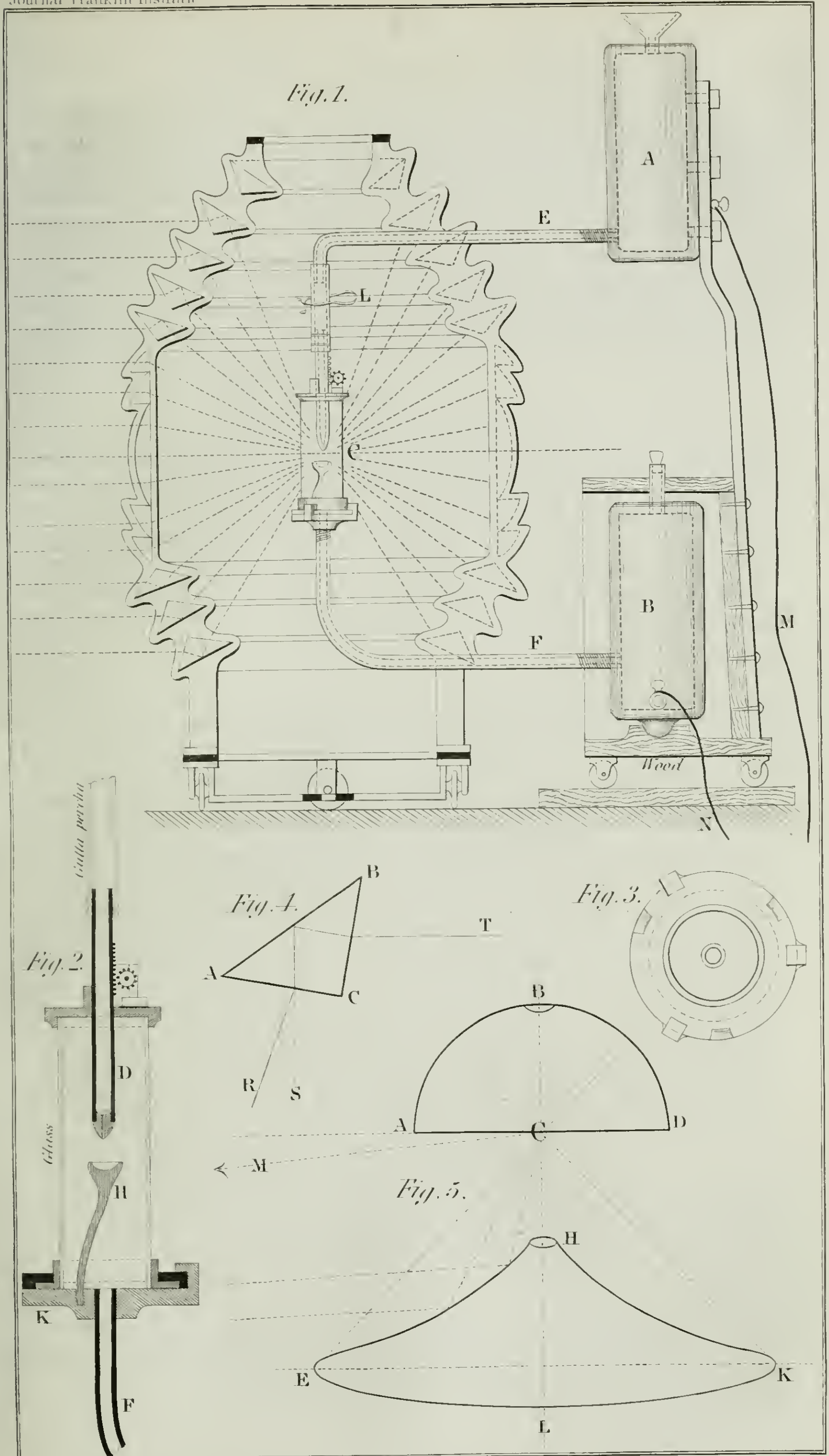


Fig. 1.
A
E
L
C
B
F
M
Wood
N
Fig. 2.
Gutta percha
D
Glass
H
K
F
Fig. 4.
B
T
A
C
R
S
Fig. 3.
A
B
A
C
D
M
Fig. 5.
H
E
K
L

The intensities of the lights were tested by looking at the shadows projected by them on a screen of whitened glass, placed at a distance of 20 yards from the electric light; the figures given above are the results of calculation, and cannot be taken as exact, though they express the differences roughly.*

The ability of the electric light to penetrate a thick, hazy atmosphere, will doubtless be one of the strongest inducements for its introduction. The sailors on board steamers plying between France and England, say they can see Prof. Holmes' light, in such weather, 7 miles further than any other.

UTILIZATION OF THE LIGHT.

The superiority of the dioptric lens over reflectors has been generally insisted upon; but Prof. Potter, of London, who has made extensive photometric experiments, doubts the great advantages which have been claimed for the Fresnel lens. He has found that about one-fourth of the light is lost by reflection and absorption in passing through a thickness of *two inches* of clear flint glass with highly-polished surfaces, and that good, ordinary looking-glass reflects *six-tenths* to *two-thirds* of the light falling upon it, and that highly-polished mirrors, of speculum metal, as used in reflecting telescopes, reflect still more.

Prof. Faraday states the absorption of light by dioptric apparatus to be 50 per cent., and that pure silver, highly polished, reflects 95 per cent. of the total quantity falling upon it.

Sir David Brewster considers a spherical mirror composed of flint glass prisms, as used in the many forms of holophotal apparatus, as greatly inferior to one made by Foucault's process.

Sir J. F. W. Herschel has recently proposed an improved reflector, which is likely to prove a great economizer of light.

With the ordinary parabolic form, part of the light is thrown upward against the sky, unnecessarily illuminating the stars; and although, in the Fresnel lens, this defect is remedied to some extent, there is still considerable loss, more especially in the catadioptric zones. This will be readily seen by referring to Pl. I., Fig. 4, where R, the ray proceeding from the focus, is refracted to the back of the prism A B C, and then reflected and refracted out towards T, whereby much light is absorbed in pursuing such a circuitous route; and when the zones or prisms are highly polished, as they usually are, there is also the additional loss by reflection towards S.

The loss from imperfect brilliancy of the ordinary plated reflectors is greatly reduced by the recent discovery of Liebig, wherein pure silver is precipitated from its solution, contained in a thin shell of glass. The silver, by this method, is protected against all the agencies which tarnish it, and it is affirmed that 91 per cent. of the light is reflected by it.

Sir J. F. W. Herschel proposes to make use of these mirrors, at the same time so arranging their shape that the losses and disadvan-

*See Report of English Lighthouse Commission, 1861.

tages due to the common form may be avoided. This is accomplished as shown in Pl. I., Fig. 5, **C** being the focal point, or source of light, **ADB** being a hollow hemispherical reflector, **EHK** a conoidal reflector, whose surface is generated by the revolution about the vertical axis, **CL**, of an ellipse whose major axis, **CM**, dips below the geometric horizon. By the above arrangement, it has been demonstrated that the most advantageous dispersion of light over the sea surface is obtained, while the entire horizon may be illuminated, if necessary, by a single flame, as in the dioptric arrangement. All the light diverging upward is turned back, and, passing again through **C**, radiates thence downward, and in effect nearly doubles the intensity.

Although adapted to ordinary oil flames, the most appropriate light is considered to be that obtained by electricity.

The Earl of Rosse in commenting upon the present defective mode of constructing reflectors of thin sheet metal, says reflectors should be cast of gun-metal (9 of copper and 1 of tin), turned in a lathe to obtain a true surface, electro-plated carefully, and finally polished in a lathe.

WASHINGTON, D.C., March, 1862.

The Shearing Strains of Deflected Girders. By HOMERSHAM COX, M.A.

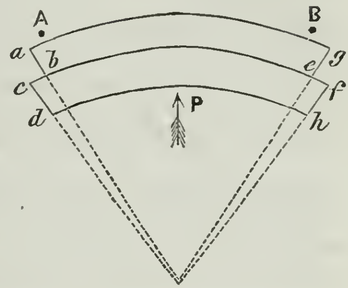
From the Civ. Eng. and Arch. Jour., Aug., 1861.

Of late years, the shearing strains of deflected girders, that is, the strains which result from the tendency of the particles of the beam to slide on the surface of each other, have received much attention. The object of this note is not to add anything to the mathematical theory of the subject, but to point out a simple case in which, with little aid from mathematics, the important effects of the tangential or shearing strength of beams are strikingly shown.

The ordinary theory of beams does not take into account the tangential displacement of particles, but supposes that those particles which are opposite to each other before deflection remain opposite after deflection, and that the only displacements are normal compressions and extensions. This assumption, though not absolutely correct, is sufficiently so where the transverse dimensions of the deflected beam are small compared with its length. In such cases, the tangential elastic forces of the material are generally sufficient to prevent any considerable tangential displacement. But the effect of those forces may be readily seen by the effect on the statical strength of a beam which would result from removing, artificially, part of them.

Suppose a horizontal straight beam, of which the section is rectangular, to be actually divided into two equal parts by a smooth section parallel to its upper surface; and suppose then the two parts of the beam remaining in contact to be deflected as in the diagram by a force or forces perpendicular to the surface of the beam, so that the deflections are equal at equal distances from the fulcra A and B. The diagram represents a section of the beam in the plane of deflection. The deflecting forces act on the concave surface of the beam. The section

a b of one end of one part of the beam will not after deflection be in the same straight line with *c d*, the section of the end of the other part, as would be the case if there were no shearing strains; but *b e* in the concave surface of the part of the divided beam next A B will be shorter than *c f* in the convex surface of the other part of the beam.



This may be seen very readily in the case where the deflecting pressures are such that the curves shown in the diagram are circular arcs. The neutral line of *a b e g* and that of *c d h f* are both equal in length, for they are both equal to the length of the beam before deflection. But the former neutral line is the arc of a circle of a radius larger than the radius of the circle of which the latter neutral line is an arc; and therefore, since the two arcs are equal in length, but have unequal radii, the former subtends a smaller angle than the latter.

In order to estimate the loss of the strength of the beam consequent on the division along *b e*, suppose only a single deflecting pressure P to act perpendicularly to the line joining A and B, the two points of support, and midway between them. Let x be the distance from B measured parallel to the straight line A B of any point in the neutral line of the beam *a b c g*; and let R be the radius of curvature of the neutral line at that point; E the modulus of elasticity of the material; I the moment of inertia of the rectangular section of the beam *a b e g* about an axis through its centre of gravity perpendicular to the plane of deflection. By the ordinary theory $\frac{\mathrm{E\,I}}{\mathrm{R}}$ is equal to the moment about the same axis of all the forces acting upon the part of the beam between the point in question and the nearest end of the beam. These forces are, the pressure of one of the abutments, and the pressures of the intervening part of the surface of the other beam *c d h f*. Let M represent the moment of the latter, and $\frac{1}{2}\mathrm{P}x$ the moment of the pressure of the abutment.

Then, $\frac{\mathrm{E\,I}}{\mathrm{R}}=\frac{1}{2}\mathrm{P}x-\mathrm{M}$. For the beam *c d h f*, taking moments about an axis through that point of its neutral line which lies in the radius R, we have $\frac{\mathrm{E\,I}}{\mathrm{R}'}=\mathrm{M}$, where M is the same moment as before, only affected by the positive sign, and R′ is the radius of curvature of the neutral line *c d h f*. Now owing to the contact of the two beams, and their being subject to no compression in the directions of the normals to their surfaces, it may easily be seen that at the points of which R and R′ are the radii, the neutral lines have a common centre of cur-

vature, and that consequently R and R′ differ in length only by the part of R between the two neutral lines. This difference is inconsiderable compared with R. We therefore have approximately (adding the two preceding equations) $\frac{2\,EI}{R} = \frac{1}{2}\,Px$.

If the beam were not divided into two parts in the manner supposed, we should have $\frac{E\,i}{r} = \frac{1}{2}\,Px$; where i is the moment of inertia of the transverse section of the undivided beam, and r the radius of curvature at the distance x from B. Now the section being rectangular, the moment of inertia varies as the cube of the distance between the convex and concave surfaces. This distance is twice as great for i as for I; consequently $i = 8\,I$. Therefore $\frac{1}{r} = \frac{4}{R}$. It follows that the deflection produced by P will be four times as great when the beam is undivided as when the beam is divided. Assuming the ultimate strength of a beam to be proportional to the moment of inertia of its transverse section, it follows also that the breaking weight at the centre of the undivided beam is four times that at the centre of the divided beam. In other words, *the effect of dividing the beam in the manner mentioned, is to reduce its strength and rigidity to one-fourth of its original strength and rigidity.*

On Measuring Distances by the Telescope. By Mr. W. B. Bray, M. Institution C. E.

From Newton's London Journal, Jan., 1862.

The author's attention was attracted to this subject by a paper, by Mr. Bowman, read before the British Association in 1841; but it required further investigation and modification, to bring it into a form of practical utility.

He found that it was convenient to have two distinct hairs on the diaphragm of the level—one about $\frac{3}{20}$th of an inch above the level hair, and the other as much below, so as to read 1 foot on the staff at 1 chain, and 10 feet at 10 chains. Since, however, in focusing the instrument to any object, it was necessary to bring the cross hairs into such new focus, which was proportionally further from the object glass as the object was nearer, the angle which the hairs subtended from the centre of the object glass must be variable, diminishing as the distance was diminished. Hence a correction was necessary, and this the theory of refraction by lenses furnished. It showed that the error was constant at all distances, amounting in every case to the focal length of the object glass for parallel rays. This constant was to be added in reading the staff, by bringing the lower cross hair near any even division of feet, but exactly ·02 of a foot above it, corresponding with the two links from the centre of the instrument to the anterior focus, in

the cases of a 5-inch theodolite and 10-inch level. Then, by reading the upper distance hair, and deducting the even number of feet at the lower hair, the difference was the distance in chains and links. If the compass was sufficiently delicate, any operation of contouring, or running trial levels, could be performed with rapidity and accuracy.—When provided with the two distance hairs, the level of the ground could be taken above and below the ordinary range of the instrument. The use of these distance hairs for eighteen years had proved their practical value. In taking the widths of rivers or deep ravines, distances of 20 chains had been read in favorable weather; and when the hairs were accurately fixed on the diaphragm, they might be used for even fractions of a link, in taking widths incapable of direct measurement.

When applied to a theodolite, they could be used for measuring distances on sloping ground. But in that case, since the line of sight was no longer perpendicular to the staff, a correction was necessary, for which a table was given, showing the angles of elevation of the various heights, which were simple fractional parts of the horizontal distance. When the horizontal distance to the staff had been ascertained, the theodolite was to be elevated to the tabular angle corresponding to the fractional rise nearest to the slope of the ground; then that fraction of the horizontal distance, less the reading of the staff, would be the correct rise. With the theodolite, it was convenient to have another set of hairs, for reading the distance in feet, as well as in links. In clear weather, with a distinct reading staff, a distance of 40 chains had been read between the foot and link hairs.

In the course of the discussion it was remarked, that the arrangement described by the author, was of much earlier date than had been mentioned. Possibly its application might hitherto have been limited, from the want of a correction for the errors introduced in focusing the instrument, which had now been supplied. Reference was made to the micrometer arrangement of the diaphragm in Mr. Gravatt's original dumpy level. This system of measuring distances had lately been applied to rifle practice, and for military purposes generally; and it was thought that a micrometer telescope could be relied on for distances, up to 12 or 15 miles. It had also been employed for determining the speed of vessels at sea, when the exact length of the vessel was known, as well as for other purposes.

It was observed that the great improver of instruments of this kind was M. Porro, an officer of Engineers in the service of Piedmont, a detailed account of whose "*Instruments pour les léves de plans*," was given by M. H. de Senarmont in the *Annales des Mines*, 4th Series, vol. xvi, (1849.) None of the modifications in M. Porro's instruments had been introduced into this country, and yet with his micrometer scale of wires, the staff could be read off in metres at once—and it was stated, at a distance of 800 metres, the error did not exceed two centimetres.

Proc. Inst. of Civil Engineers, Nov. 19th, 1861.

For the Journal of the Franklin Institute.

On the Practical Limits to Economy from the Expansive use of Steam.

The laws which govern the action of steam in the production of power, indicate a large economy from its use when allowed to expand after communication with the boiler has been closed. Experience has, within certain limits, seemed to verify this indication, and the economy due to expansion has become almost a dogma in engineering

Within a very few years, some have been found bold enough to question the value of this generally received opinion, and have instituted experiments for the purpose of demonstrating its truth or falsity. It is not easy to make *reliable* experiments on this subject, upon such a scale as would in practice entitle their results to credit.

It *is* easy to try experiments apparently conducted with care on any given engine, observing the effect of different rates of expansion, which, however correctly observed or noted, are utterly valueless in determining the true point at issue. For from the nature of the case, they having been tried on the *same* engine, with the *same* load, the conditions of a true comparison have not been fulfilled; viz: that the conditions be the same. It is evident that in such a case, varying the rate of expansion, involves for the maintenance of uniform power, (*mean* pressure) a change of initial pressure. A mean pressure for example, of 20 pounds, requires, when working at full stroke, 20 pounds initial pressure; when cutting off at one-third stroke it requires $28\frac{1}{2}$ pounds, or more than forty-two per cent. more, &c.

Consequently it is seen, that in the case described, which is almost the only kind ever tried having this object, *two* changes are made, first, a change in the rate of expansion; secondly, a change in boiler or initial pressure. Nor can the difficulty be overcome by throttling. There is a certain loss from condensation when steam is expanded, whether the expansion takes place at the throttle or the cut-off valve. If, then, steam be generated of the pressure required for the high rate of expansion, it ought to be *used* at that pressure with the low rate of expansion. It needs no argument to show that this is simply impossible when the same engine is used to drive the same load.

Apart from the varying degree of economy with which steam of different pressures can be generated, a change of maximum boiler pressure affects the loss by radiation and leakage, and, more important still, the question of cost, size, and weight of the machinery required. If a boiler is to be constructed for a working pressure of twenty pounds per square inch, if an engine is to be designed for such pressure, the cost and weight of both will be less than if thirty pounds is to be the limit.

Now these conditions of size, cost, and weight, are precisely those most important in a practical point of view, next to economy, but are apt to be left out of the question by the theorist.

The true practical question at issue is simply this: *Given*, a standard maximum steam pressure, and a standard maximum resistance, at what rate of expansion shall the steam be used to produce the best and most economical results, all things considered?

By "all things" I mean principally, economy of first cost, of wear and tear, of fuel, space and weight. Stated in more concise terms it stands thus: Are large or small cylinders best for the development of power economically?

The solution of the question depends on considerations partly theoretical, partly practical; while they may be enumerated in terms sufficiently concise, their value and true bearing can be ascertained only by properly conducted experiments.

Some of the causes which may operate in favor of using smaller cylinders, or a lower rate of expansion, are as follows:

1. The condensation of steam due to, and inseparable from, its expansion when communication is cut off from the water from which it has been generated; the amount of loss from which is greater, the further the expansion is carried.
2. The heat taken from the steam to evaporate, at continually reduced pressure consequent on expansion, the water previously condensed from it; the amount of which loss increases as the rate of expansion is raised.
3. The loss of heat from radiation, externally and internally from the surfaces of the cylinder and heads; it being greater as the size of cylinder is increased.
4. The amount of steam lost in filling the ports and clearances of the cylinder, which, although producing a small dynamic effect, increasing with the rate of expansion, is, nevertheless, a positive loss, greater in ratio of the size of cylinder.
5. The tension of vapor on the exhaust side of the piston, or back pressure, a constant resistance for any rate of expansion, necessarily increases in amount, the greater the size of cylinder.
6. The pressure required to overcome the resistance of the engine alone, doing no work, simply overcoming the friction, working the pumps, &c., and maintaining the velocity; which is ordinarily from $1\frac{1}{2}$ to $2\frac{1}{2}$ pounds per square inch in a well proportioned engine, and is of course, in proportion to its size, or that of its cylinder.
7. Cost, space, and weight, increase in proportion to size of cylinder, as also does the expense of wear, of oil, of renewal, &c.

In favor of the larger cylinder, rendered necessary to obtain the supposed benefit from expansion, it has been urged that the surplus pressure exerted before steam is cut off, acts beneficially in overcoming the inertia of the moving parts of the engine. This argument appears to me fallacious. In a well designed engine (intended to rotate a shaft for giving off its power) the reciprocating parts should combine as *little weight* as possible with the requisite strength and rigidity; by which the inertia and momentum are reduced to a minimum, and are overcome by that of the mass in rotation. Such an engine, when at work, is supposed to be moving at uniform speed. Its revolving parts have therefore no inertia to overcome due to change in direction of motion, and that of the reciprocating parts at each change of direction, if properly designed, is comparatively so little,

that it does not affect the speed perceptibly. So far from being a benefit, a surplus pressure at the beginning of each stroke, and a deficient pressure at the end of it, are positively injurious, and will infallibly tell upon the working of the engine, and in its bills for repairs if carried to an extreme.

With engines which do not communicate their power through a shaft, but which, like the Cornish engine, either operate directly on the resistance, or upon a mass which in its turn overcomes the resistance, in either case starting each stroke from a state of rest; the whole aspect of the case is changed. Here an excessive impulse is required in starting the load, to overcome suddenly its inertia. The great power thus stored up is not expended until long after steam is shut off, and indeed long after it has ceased to impel the mass; which finally when its momentum is expended, stops. In this case a large cylinder is necessary; and as a consequence, a high rate of expansion. But the great economy of this class of engines is mostly due, not to expansive working, but to the peculiar application of the power. At least, because a large cylinder and high expansion may apparently produce benefit in this case, we have no right to anticipate equally good results from the same things applied under different practical conditions.

It has been before stated that the value or effect of the various causes, tending to modify the theoretical gain from expansive working, could be determined only by properly conducted experiments; and that the experiments generally tried with this object in view were not so conducted.

To fill this want of the profession, a Board of Naval Engineers of the United States, made by authority in November, 1860, on the steamer *Michigan*, a series of experiments, which, for care and elaboration are not surpassed, if equalled, by any others recorded of a similar nature.

The conclusions of the Board, and their method of conducting the experiments, have been the subject of controversy in this Journal. It is not my purpose to enter into a discussion upon, or to defend, the course pursued by the Board. Each reader of their report who approaches it with an impartial spirit and a desire to attain a true understanding of so important a subject, will probably form his own conclusions.

After a very careful stndy of it, I am satisfied that some misconceptions exist on the subject, and that, rightly construed, their suggestions are entitled to grave consideration.

The method adopted in making their investigation was to vary the load in such a manner as to maintain with the same boiler pressure, the same *mean* pressure with different rates of expansion. This proceeding was equivalent to varying the size of cylinder, the boiler pressure and load remaining the same.

The method adopted in comparing results, was to adopt as a standard of power developed, the amount of water pumped into the boilers: thus eliminating every thing appertaining to quality of coal, methods

of firing, relative amount of boiler and grate surface, &c., the weak point in comparisons where great accuracy is required.

It does not appear that in any respect, the care and attention requisite in such researches, were wanting. The tank was placed in such a position as to prevent the possibility of unknown leakage; and each trial extended uninterruptedly over 72 hours. The machinery was of size sufficient to make the results valuable practically, and it is probable, was in better condition generally, than marine machinery ordinarily is when in service.

The boiler pressure was kept throughout the trials at 20 pounds above the atmosphere, or 34·7 pounds total. The "back" or condenser pressure averaged 2·7 pounds (an unusually low figure, it being generally at least one pound higher—the difference being in favor of high expansion).

Without taking into account the power consumed in engine resistance, the following results were obtained:—

Points of cut off,	$\frac{11}{12}$	$\frac{7}{10}$	$\frac{4}{9}$	$\frac{3}{10}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{4}{45}$
Economic result,	1·000	0·889	0·859	0·912	0·906	0·967	1·088

It is apparent that an increase of boiler pressure would modify this comparison, because the back pressure remains the same, while the mean pressure is decreased with increasing rates of expansion; consequently acting more injuriously on the nett power at higher rates. To show, however, that modification from this cause is not great, the following table gives the comparison of different rates of expansion, without allowing for any back pressure:—

Point of cut-off,	$\frac{11}{12}$	$\frac{7}{10}$	$\frac{4}{9}$	$\frac{3}{10}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{4}{45}$
Economic result,	1·000	0 882	0 840	0·874	0·852	0 877	0·915

When the effect of engine resistance equal to 1·7 pounds per square inch, as well as back pressure, is taken into account, the results are as follows:—

Point of cut-off,	$\frac{11}{12}$	$\frac{7}{10}$	$\frac{4}{9}$	$\frac{3}{10}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{4}{45}$
Economic result,	1·000	0·896	0·877	0·949	0·962	1·065	1·292

This table contains the *substance* of the whole set of trials. For as no engine can work without back pressure and its own resistance, it is the nett power, after deducting these two resistances, which must be compared. The amount (ascertained by experiment) for the latter of these elements is low, and shows the engine to have been in good condition; it generally varies in well designed engines from 1·5 to 2·5 pounds.

It thus appears that the most economical point of cut off is $\frac{4}{9}$, then $\frac{7}{10}$, $\frac{3}{10}$, $\frac{1}{4}$, $\frac{11}{12}$, $\frac{1}{6}$, $\frac{4}{45}$.

Those who find it difficult to accord these apparently extraordinary results with what they have observed in practice, overlook the fact that their observations have been made on the *same* engine, whereby they have ignored the modifying effect which would have resulted

from the employment of a properly proportioned cylinder; *i. e.* a cylinder of such size as would preserve the mean pressure the same.

The following table gives these proportions:—

Point of cut-off,	$\frac{9}{10}$	$\frac{8}{10}$	$\frac{7}{10}$	$\frac{6}{10}$	$\frac{5}{10}$	$\frac{4}{10}$	$\frac{3}{10}$	$\frac{2}{10}$	$\frac{1}{6}$	$\frac{1}{8}$
Size of cylinder,	1·000	1·010	1·032	1·115	1·207	1·359	1·615	2·160	2·494	3·181

It is calculated for an initial pressure 30 pounds above the atmosphere, 3 pounds back pressure, 2·1 pounds engine resistance.

To show that this change does produce an important effect on economic results, the following calculations are here introduced:—

Suppose an engine of 60 ins. diameter of cylinder, 3 feet stroke, with clearance space equalling 3 ins. of stroke, in which steam of 30 pounds (above atmosphere) is cut off at 3-10 stroke, back and engine resistance as above.

Steam consumed each half revolution.

3 ft. × 3-10 = 0·90 ft. + 0·25 clearance = 1·15 feet.
Area 2827 sq. in. = 19·63 sq. ft. × 1·15 = 22·574 cub. ft. of a density 613·6 gives ·03679 cub. ft. water used.

Power developed.

2827 × 44·7 total press. × ·662 coeff. = 83650·93
Less back pressure, 3·0
And engine resistance, 2·1

2827 × 5·1 = 14417 70

Nett pressure, . 69233·23 lbs.
And 69233·23 × 3 feet stroke = 207699·69 ft.lbs. exerted each half revol.

If now the same cylinder be used cutting off at 7-10, the steam consumed will be—

3 ft. × 7-10 = 2·10 + 0·25 = 2·35 × 19·63 = 46·130 cub. ft.

Power developed will be—

Back and engine resistance as before, 14417·70
Nett pressure, . . 69233·23

Gross " . . 83650·93 ÷ 2827 = 29·59 pounds.

Coeff. of 7-10 = ·951, therefore $\frac{29{\cdot}59}{{\cdot}951}$ = 31·11 initial pressure, of which density is 854·5.

Hence the Water used will be $\frac{46{\cdot}130}{854{\cdot}5}$ = ·05397 cub. ft.

Comparing these two results from the same cylinder,

Cutting off at 3-10 steam consumed 0·3679 or 1·000
to
" " 7-10 " " ·05397 1·467

the same nett power being produced.

But suppose the cylinder diminished so that the same pressure may be maintained equal 30 pounds until cut off at 7-10 stroke.

Power (nett) as before, = 69233·23 obtained with steam, initial pressure, $\left\{\begin{matrix}30\ 00\\ 44{\cdot}70 \text{ total}\end{matrix}\right\}$ cut off at 7-10, coeff. = ·951 = 42·51
Less back pressure and engine resistance = 5·10

Nett pressure throughout stroke, in pounds per square inch, 37·41

Area of cylinder = $\frac{69233{\cdot}23}{37{\cdot}41}$ = 1850 sq. ins. = 48½ ins. dia.

Steam consumed.

3 ft. × 7-10 = 2·10 + 0 25 = 2·35.
Area 1850 sq. ins. = 12·84 × 2 35 = 30·171 cub. ft., of a density = 613·6 or ·04917 cub. ft. of water.

Comparing this result with that from the larger cylinder, we see that the ratio between 3-10 cut off there and 7-10 here is

With large cylinder cutting off at 3·10	·03679 or	1·000
		to
With small " " " " 7-10	·04917	1·336

The advantage of using the proper size of cylinder in this case, to obtain the same power, is as

1·467 to 1·336, the difference, on the unit of power with high expansion, being over 13 per cent.!

This it will be remembered is purely the result of loss by clearance, back pressure, and engine resistance. To reconcile the theoretical economy still existing, with the observed results, we must refer to the other sources of loss referred to earlier in this paper. When it is remembered that the internal and external surface is one-third greater, that the terminal pressure is less than one-half, that the terminal temperature is reduced from 233° to 196°, that expansion (involving condensation) is carried to double the extent, on three-fourths the weight of steam, or to one-half greater extent on the same weight, in the larger cylinder, it will be less difficult to reconcile the theory and the results.

Add to these considerations, that we have an engine to build and preserve in good condition, which will not cost over 80 per cent. that of the larger one, of a simpler character, of less weight, and occupying less space, and we are more disposed to accept the results than the theory.

At all events, if these arguments possess any weight, it would seem that the suggestion made by the Board as a result of the Erie Experiments, to wit, that for general purposes rotating engines should be designed for a maximum resistance requiring steam to be cut off at $\frac{7}{10}$ stroke, is practically a tenable position. The link motion, or some simple valve gear, would enable this cut-off to be shortened to $\frac{1}{2}$ stroke, with an economy nearly the same as if that had been the normal point of cut-off intended.

The advantages to be derived from complicated mechanism for expansion gear, to obtain "sharp corners" on the cards, and for varying the cut-off from nothing up to full stroke, are rendered by such an argument exceedingly mythical.

Not that they may not produce benefit when applied to any given engine already in use for doing a certain work, which has been designed too large for that work; but that *better* results might be obtained by proper proportions in engines designed on the basis indicated.

It is from the foregoing evident, that the labors of the Erie Board cannot greatly modify existing practice; but I am disposed to think they will in time modify existing ideas, which will hereafter produce their proper fruit. J. V. M.

PHILADELPHIA, March, 1862.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Analysis of the Gamut in the Major and Minor Modes. By C. J. W., Jr., Germantown, Pa.

(Continued from page 182.)

By examination of the table of modulations above, it will be observed that we have, by successive steps, gradually approached the key of Do natural with which we set out; and that we have finally reached it, by the introduction of twelve flats into the signature. The keynote of twelve flats is actually the note Re double flat, and Re double flat is practically the same note as Do natural. We have thus in three different ways produced the keynote of Do natural, or its equivalent; first, by dispensing totally with the use of flats and sharps; next, by the introduction of twelve sharps into the signature; and lastly, by the introduction of twelve flats into the signature. It will now be shown that this is by no means a solitary instance of the existence of identical keys, but on the contrary, that each key represented by sharps has its counterpart, though under a different title, to be found represented by flats.

For instance: by reference to the table of consecutive sharps, it will be seen that the key of four sharps is the key of Mi or E natural. But Mi natural is equivalent to the note Fa flat, and by reference to the table of successive flats, it will be found that the key of Fa flat is the key of eight flats.

The keys therefore of four sharps and eight flats are identical.

Again: by reference to the same tables, it will be seen that the keynote of two sharps is Re or D natural; but the note Re natural is identical with the note Mi double flat, and Mi double flat is the keynote of ten flats. The key of two sharps, therefore, is identical with the key of ten flats.

In the same manner it may be shown that the keys of three sharps and nine flats are identical; that the keys of five sharps and seven flats are identical; and generally, that the key represented by any number of sharps, is identical with the key represented by that number of flats which added to the number of sharps, makes twelve. The only difference between identical keys thus represented by flats and sharps, is that minute fraction of a tone existing between the augmentation of any note by a sharp, and the diminution of the succeeding note by a flat—the interval between the two notes being premised to be a full tone. The transposition from one of these keys to another is technically defined by the term, *inharmonic change.* Thus a transposition from Do sharp to Re flat, or from Re sharp to Mi flat, is an illustration of the change in question. As each of these pairs of notes are represented upon the piano and other keyed instruments by one key, the change or transposition alluded to has but a theoretical existence as far as these instruments are concerned; with stringed in-

struments, however, the case is quite different, and the distinction appreciable—one evidence of their greater perfection.

To those accustomed to keyed instruments, and who have not reflected upon the subject, the assertion of identity between keys represented by unequal numbers of flats and sharps, may seem paradoxical, inasmuch as it would appear that flats and sharps being represented by black keys exclusively, upon such instruments, the two sharps belonging to the key of Re, for instance, would require the use of two black keys. while the ten flats of its counterpart, the scale of Mi double flat, would require the employment of ten. This, however, is obviously an incorrect conclusion, for it must be recollected, that just as the black keys are required to represent either flats or sharps, as the case may be, so do the white keys represent double flats and double sharps, as well as the normal notes from which they derive their names—being the nearest approximation thereto, of which the imperfect construction of the instruments will admit.

For example: it will be found that in the scale of ten flats, or Mi double flat, there exist three notes twice flattened, viz: E, B, and A—together with the notes C and F, once flattened, all of which notes are to be represented by white keys. There remain, therefore, but two notes, D flat and G flat, to be represented by black keys, and these same keys are those brought into requisition in order to make the two sharps, F and C, belonging to the corresponding scale of Re natural.

The existence of corresponding keys, represented by flats and sharps, being thus sufficiently established, and the object of the writer being rather to analyze, than to suggest rules, the rationale of the one in question will now be investigated. In order to simplify the demonstration, and avoid the complication consequent upon the introduction of fractional quantities, the octave will be divided into the twelve semitones of which it is composed; a semitone being considered throughout the investigation as the unit of measure.

It will therefore be borne in mind, that the octave consists of twelve semitones; the fifth, of seven semitones; and the fourth, of five semitones, or units of measure. We shall commence our inquiry with the natural key of Do—that key affording one of the simplest forms for the application of the rule—and propose to show why the introduction of twelve sharps into the signature should restore the scale to the same keynote again—or rather, to its equivalent—the key of B sharp.

Now as the octave contains twelve semitones, and we have seen that the addition of each sharp raises the key a fifth, or seven semitones, it is evident that the addition of twelve sharps will raise the keynote a distance of eighty-four semitones. But eighty-four semitones is precisely seven octaves; the keynote therefore has completed its revolution of the circular octave, just seven times, and has thus reached the point whence it set out.

It is therefore clear, that the addition of twelve sharps to the natural key must restore the keynote to the position which it occupied originally.

We will now, however, take a more complicated example.

Suppose that one flat be introduced into the natural scale: we shall then have the key of Fa natural, and it is required to show by the addition of how many sharps, to the natural scale, the keynote may be made to reach a similar point.

As has already been seen, the addition of one flat advances the keynote the interval of a fourth, or five semitones, and the addition of each sharp, advances the keynote the interval of a fifth, or seven semitones. The keynote, therefore, by the addition of each sharp, performs a revolution of the octave, less five semitones. If, therefore, a sufficient number of incomplete revolutions be performed, so that this number multiplied by five—the number of units lost in each revolution—added to five—the number of units which the keynote is advanced by the flat introduced—shall be a sum divisible by seven without a remainder, then this number of revolutions, added to the multiple that this latter sum is of seven, must be the number of sharps required.

In the present instance, thirty-five being the product of five and seven—thirty-five less five—or thirty—is the number to be lost by the incomplete revolutions of the keynote—or in other words—by the addition of sharps to the signature. As five is lost in each revolution, six of these partial revolutions, or six sharps, will be required to accomplish this result. The number six, therefore, added to five—the number of times that seven is contained in thirty-five—making eleven, is the number of sharps required to place the keynote in the position to which it has been raised by the introduction of one flat into the signature of the natural scale.

For a third example, suppose that another flat be introduced into the signature. We shall then have modulated into the key of Si flat, and raised the keynote two fives, or ten semitones above its original position.

Now thirty-five less ten, equals twenty-five—and twenty-five is the number to be dropped by the revolutions of the keynote. Dropping five in each revolution, it will require five revolutions, or five sharps, to accomplish this. Five therefore added to five—the number of times that seven is contained in thirty-five—gives ten for the number of sharps required to form a key corresponding to the key of two flats.

From the examples given above, it is evident that thirty-five, or the product of five and seven, is a constant quantity in the formula, and, therefore, for every additional flat—or five that the key is advanced—five less of this product remains to be dropped by the revolutions of the keynote effected by the addition of sharps: and as twelve was shown to be the number of sharps required to produce a return of the keynote to the place which it occupied in the natural scale, so the introduction of every flat requires a corresponding omission of sharps for its equivalent key thus represented—that is, a number of sharps equal to twelve, less the number of flats introduced.

The investigation of the above rule evidently points to a property of numbers, which, in the case before us, is but specially applied. It may be thus generally enunciated.

If any number be divided into two parts, and also into other two parts; then will the difference between the product of the greater of the first division with the greater of the second, and the product of the lesser of the first division with the lesser of the second, be equal to the product of the whole number with the difference between the greater of either division and the lesser of the other: Also, will the difference between the products of the greater of each division with the lesser of the other division, equal the product of the whole number with the difference between the two greater, or the two lesser of each.

In the particular case before us, *twelve*—the number of units into which the octave has been divided—represents the whole number: seven and five—the number of semitones or units contained in a fourth and fifth respectively—represent the first division, which is constant. The second division—representing the number of flats and sharps required to produce corresponding keys—is variable.

For example: if four be the number of flats in a given key, then will four and eight represent the second or variable division. Here seven and eight will be the two greater, four and five the two lesser, and three, the difference between the greater of either division and the lesser of the other.

Hence, by the rule, we shall have seven multiplied by eight, less five multiplied by four, equal to thirty-six; and thirty-six equals three multiplied by twelve.

Thus, using the signs, $7 \times 8 - 5 \times 4 = 56 - 20 = 36 = 12 \times 3$.

Also, will eight multiplied by five—the product of the greater of one division with the lesser of the other—less seven multiplied by four—the lesser of the one with the greater of the other—equal twelve multiplied by one; or, the whole number multiplied by the difference between the two greater or the two lesser of the divisions.

Thus, $5 \times 8 - 7 \times 4 = 40 - 28 = 12 = 12 \times 1$.

The rule however, as before stated, is of general application; we will, therefore, apply it to some other number.

Suppose, for example, that fourteen be divided into two parts—ten and four—and into two other parts—eight and six. Then by the rule will ten multiplied by eight, less six multiplied by four, equal fourteen multiplied by four.

Thus, $10 \times 8 - 6 \times 4 = 80 - 24 = 56 = 14 \times 4$.

Also, ten multipled by six, less eight multiplied by four, equals fourteen multiplied by two.

Thus, $10 \times 6 - 8 \times 4 = 60 - 32 = 28 = 14 \times 2$.

Or generally, let $a =$ any number, and let it be divided into two parts,

$x =$ greater part, and

$(a - x) =$ lesser part.

Let $y =$ greater part of the second division; then

$(a - y) =$ lesser " " "

Then $xy-(a-x)(a-y)=a[x-(a-y)]$; that is,

$xy-a^2+ax+ay-xy=ax-a^2+ay$, which, omitting the similar terms, reduces to $a=a$.

Also, $x(a-y)-y(a-x)=a(x-y)$; that is,

$ax-xy-ay+xy=ax-ay$, which, by reducting, results likewise in $a=a$.

The rule which we have above demonstrated may be proved in yet another way, without the introduction of semitones as units of measure.

It has already been seen, that in order to find the keynote required by any number of sharps, it is only necessary to divide, by seven, the product of this number of sharps with the number four, the remainder giving the number of notes intervening between Do natural and the keynote of the scale proposed.

It has also been shown that the number of flats, required to form a key corresponding with one represented by sharps, is the difference between the number of sharps and the number twelve; and further, that the product of this difference with the number three, divided by seven, will leave a remainder equal to the number of notes intervening between Do natural, and the keynote of this corresponding key of flats. It has also been shown, that this latter number will exceed by unity the number previously found, relating to the scale of sharps, for the simple reason, that a note considered as a sharp takes its name from the note preceding by one tone, the note from which the name of the same note considered as flat, would be derived.

These results furnish us with another formula which directs to a property of the number twelve; though not, as in the previous case, a property of general application.

It may be thus briefly stated:

If the number twelve be divided into any two parts, and also into its factors three and four; then will the remainder—after the division of the product of either of these parts with the lesser factor, by the sum of the factors—exceed by unity, the remainder—after the division of the product of the other part with the greater factor, by their sum.

Suppose for example, the number twelve be divided into two parts—eight and four; then will the remainder—after the division of the product of either eight or four with the lesser factor, three, by the sum for the factors, seven—exceed by one, the remainder, after the division by the same number, of the product of the other part with the factor four.

Thus, $4\times 3=12$, $\frac{12}{7}=1$, with 5 for a remainder, which exceeds

by *one* the number 4, which is the remainder of $\frac{8\times 4}{7}=\frac{32}{7}=4+4$.

Likewise, $8 \times 3 = 24$, $\frac{24}{7} = 3$, with 3 for a remainder, which is greater by *one* than the remainder of $\frac{4 \times 4}{7} = \frac{16}{7} = 2 + 2$.

In every instance, as may be seen, the part multiplied by the lesser factor, when divided by the sum of the factors, has a remainder greater by one, than the remainder, after the division of the product of the other part with the greater factor, by their sum.

The property above stated, may, like its predecessor, be readily demonstrated analytically.

Thus, let a, be any part of the number twelve; then will $12 - a$, be the other part.

Let y, be the integral part of the division of the product of the part a, with the greater factor 4, by the sum of the factors 7—and let x, represent the numerator of the fractional part of the same division.

Let z, be the integer of the division, by the sum of the factors, of the product of the other part $12 - a$, with the lesser factor 3; then will $x + 1$ represent the numerator of the fractional part of said division.

By the hypothesis, $\frac{4 \times a}{7} = y + \frac{x}{7}$, from which we obtain

$$4\,a = 7\,y + x, \text{ or } x = 4\,a - 7\,y.$$

Also, by hypothesis $\frac{3\,(12 - a)}{7} = z + \frac{x + 1}{7}$, whence

$$36 - 3\,a = 7\,z + x + 1, \text{ or by transposition,}$$

$$x = 36 - 3\,a - 7\,z - 1 = 4\,a - 7\,y. \text{ Whence,}$$

$$7\,a = 7\,y - 7\,z + 35, \text{ or } a = y - z + \frac{35}{7}.$$

From the conditions thus deduced, it is evident, that as y and z are by hypothesis whole numbers, their difference is likewise a whole number; and, that as $\frac{35}{7}$ is a whole number, the part a, must also be a whole number—for the difference between two integral numbers, increased by an integer, cannot be fractional; a, therefore, representing any part of twelve not fractional, the conditions will be fulfilled. Q. E. D.

The deductions further show, that the conditions essential to the possession of this property by a number, are, that the product of the number with its lesser factor, when diminished by unity, shall be divisible without a remainder by the sum of the factors; the factors differing from each other but by unity.

This latter property may likewise be shown to belong only to the number twelve. Thus, if y, and $y + 1$, be two factors of any whole number, then will their product be $y^2 + y$—and represent the number

—while $2y + 1$, will be their sum. It is proposed to find such a value for the factor y, as shall render the fraction $\frac{y(y^2 + y) - 1}{2y + 1}$, integral.

By actual division, we shall have, $\frac{y^2}{2} + \frac{y}{4} - \frac{1}{8} - \frac{7}{8(2y + 1)}$, the integral qualification of which cannot be impaired by multiplying by 8. This performed, we shall have, $4y^2 + 2y - 1 - \frac{7}{2y + 1}$ integral.

Now, as the first three terms of this formula are integral, (y being so by hypothesis,) they may be dispensed with, and there remains but the fractional form $\frac{7}{2y + 1}$ to be considered. This last term will evidently be integral, if $2y + 1 = 7$, or -7 (in which case $y = 3$, or -4), or, if $2y + 1 = 1$, or -1: in which case $y = 0$, or -1, and the factor, $y + 1 = 1$, or 0: in either event, one factor equaling 0, the number is imaginary.

In case $y = 3$, or -4, $y + 1 = 4$, or -3: the factors sought, therefore, are 3, and 4, or -3, and -4, the product of both of which is 12. Twelve, therefore, is the only number to which the property above enunciated belongs.

The investigation of this subject in its most general form, gives rise to the following problem:—

It is required to find two integral factors—differing from each other but by unity—any portion of the product of which, multiplied by the lesser factor and divided by their sum, shall have for the numerator of its fractional part, a sum greater by one than the numerator of the fractional part of the division, by the sum of the factors, of the product of the greater factor with the remaining portion of the product of the two factors.

Let y, and $y + 1$, be the factors proposed; then $y^2 + y$ will be their product, and $2y + 1$, their sum.

Let a represent any portion of the number $y^2 + y$; then $y^2 + y - a$ will represent the remaining portion.

Let z and v represent respectively the integral portions of the two divisions, by the sum of the factors, of the products of the factors singly, with the parts into which the number $y^2 + y$ is divided; and let b represent the numerator of the fractional portion of the division by the sum of the factors, of the product resulting from the multiplication of the lesser factor with one portion of the number $y^2 + y$. Then, we have $\frac{(y^2 + y - a)y}{2y + 1} = z + \frac{b}{2y + 1}$; and it is required to find such a value for y, as shall render $\frac{a(y + 1)}{2y + 1} = v + \frac{b - 1}{2y + 1}$.

By actual division, we have

$$\left.\frac{y^3+y^2-a\,y}{2\,y+1}=\frac{y^2}{2}+\frac{y}{4}-\frac{1}{8}-\frac{a}{2}+\frac{\frac{1}{8}+\frac{a}{2}}{2\,y+1}\right\} \quad . \quad . \quad . \quad 1;$$

and

$$\left.\frac{a\,y+a}{2\,y+1}=\frac{a}{2}+\frac{\frac{a}{2}}{2\,y+1}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 2.$$

The fractions of the first of the formulæ will evidently vanish—except the fifth term—when multiplied by 8; and, in order that their relative values may be preserved, the second formula must likewise be multiplied by the same number. We shall thus have,

$$\left.4\,y^2+2\,y-4\,a-1+\frac{1+4\,a}{2\,y+1}\right\} \quad . \quad . \quad . \quad . \quad . \quad 3;$$

and

$$\left.4\,a+\frac{4\,a}{2\,y+1}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 4.$$

Now all the terms, but the last, in each of these formulæ, are evidently integral (a and y being assumed to be integral); and, as the condition imposed is, that the difference between the numerators of the fractional portions of these two divisions shall be *one*, it will now —since the multiplication by 8—have been increased eight-fold; and, as $1+4\,a>4\,a$, by 1; 7 added to $1+4\,a>4\,a$, by 8. The fractional portion of the third formula, therefore, must be increased by $\frac{7}{2\,y+1}$, in order that the conditions imposed may be fulfilled. But, if $\frac{7}{2\,y+1}$ be added to one term of the formula, it must necessarily be deducted from another; $\frac{7}{2\,y+1}$ must therefore be deducted from the integral portion of the third formula. Now, $\frac{7}{2\,y+1}$ is, in form, fractional, and cannot be deducted from an integral quantity without destroying its integrality, unless it be in itself integral. $\frac{7}{2\,y+1}$, therefore, is integral, and this, as before shown, gives $y=3$ or -4; and, for the factors required, 3 and 4, or -3 and -4. The product in either case is 12.

Twelve, therefore, is the number that may be divided in such a manner as to fulfil the conditions prescribed.

It is evident, from the above, that the formulæ introduced will remain unchanged, whatever may be the difference required in their fractional parts. In order, therefore, to find the lesser factor, the following general rule may be applied:—

Multiply the difference required, by eight, and deduct two from the product; one-half the remainder will be the factor required.

If c represent the difference proposed, and y the lesser factor, then $\frac{8c-2}{2} = y$.

Upon the subject of minor scales, there remains but little to be said. It is well known that the keynote of the relative minor of any major scale, is to be found a minor third, or three semitones, below that of the major proposed. In order, therefore, to find the number of sharps or flats required in the signature of any minor scale, it is only necessary to add three semitones to the keynote of such minor for the keynote of its relative major; having found this, the signature required will be readily discovered.

Any major key may be converted into a minor by the addition of three flats to the signature, observing that each flat is to be considered as canceling one sharp, where any sharps exist. Thus, the key of A natural is the key of three sharps; adding three flats to the signature precisely cancels the sharps existing: the key of A minor is the result.

Again: the key of two flats is the key of B flat major; three flats added to this forms the key of B flat minor. Now, the relative major of B flat minor, would be the key of D flat, which is likewise the key of five flats.

Again: any minor key may be converted into a major by the addition of three sharps to the signature, each sharp being considered as canceling one flat, where flats exist.

For example: to the signature of Do minor—which is three flats—add three sharps; the flats being canceled, the result is the key of Do major, or the natural key.

For a second example, to the signature of G minor—which is two flats—add three sharps, the flats already existing will cancel two of these sharps, leaving but one sharp in the signature. There results the key of one sharp, or of G major.

The flats and sharps alluded to in the above remarks, are those only which appear in the signatures of the respective scales, the accidentals being in no wise referred to.

The rules thus applied to minor scales, are in perfect accordance with the principles already investigated in this article. The addition of three flats to any major scale elevates the keynote precisely three semitones, or a minor third.

The keynote, therefore, corresponding to the scale thus modified, considered as a major, would be found just this minor third above its present position; the relative minor of this major would, consequently, be placed three semitones lower, or in the position which it occupied in the original scale. The keynote, therefore, by the addition of three flats, has remained unchanged; the scale alone having been changed from a major to a minor mode.

By the addition of three sharps to a *minor* scale, the effect is re-

versed, for the key by this means is *reduced* a minor third. As the keynote of the relative major of any minor scale is to be found three semitones above that of the minor, and as the introduction of sharps proposed reduces the keynote by a similar interval, it will, when thus modified, be found to occupy the same position which it held in the original minor scale—without alteration of the position of the keynote, therefore, the scale has been transposed from the minor to the major mode.

In the reduction of the keynote of a major scale, by three semitones, in order to find its relative minor, it is evident that the first semitone of the major scale which existed between the third and fourth, will be placed between the fifth and sixth of the new scale; the note that stood third in the major scale, thus becoming fifth in the minor. Unless modified by an accidental, these are the proper positions. There are thus but two full tones composing the interval between the first and second semitones of the minor mode. when uninfluenced by other flats or sharps than those already appearing in the signature, as required by the relative majors.

In the ascending scale, this arrangement does not obtain, a semitone being always required between the seventh and eighth, to effect which an accidental is indispensable. In the descending scale, the semitones, on the contrary, occupy precisely the positions indicated by the signatures of their relative majors. In these, therefore, the accidentals are omitted.

November, 1861.

On a Boiler, Engine, and Surface Condenser, for very high pressure Steam with great Expansion. By Alexander W. Williamson, Ph. D., and Mr. Loftus Perkins, of London.

From Newton's London Journal, Jan., 1862.

The boiler, engine, and surface condenser, forming the subject of the present paper, were designed, constructed, and worked by the authors with a view to promoting the adoption of very high pressure steam with great expansion; the engine is of 60 horse power, and works at a pressure of 500 pounds per square inch, as it was thought desirable to adopt at once appliances suited for considerably higher pressures than those proposed for general use. Although, however, it has been endeavored to make a boiler which would be safe at any attainable steam pressure, it is not considered necessary by the authors, for the present requirements of steam engines, to use pressures above 140 to 160 pounds per square inch; and the practical object of the present paper, is to give substantial grounds for confidence in working at such moderate pressures; and to show how, with steam at these moderate pressures, engines, free from the most serious drawbacks of ordinary expansive engines, can be made to work with a consumption of 1 to $1\frac{1}{4}$ pounds of coal per horse power per hour. As the use of impure fresh water or of salt water is attended with a variety of incon-

veniences and disadvantages, which are more serious the higher the pressure that the boiler is worked at, it appears indispensable to use a surface condenser for an engine working at high pressure; so as to condense, in a pure state, all the steam that goes out of the boiler, and supply nothing but distilled water by the feed pump; and several important incidental advantages are gained by this plan.

The boiler consists of a number of horizontal straight wrought iron tubes, arranged in sets in parallel layers. These tubes are welded up at the ends, and connected with one another by smaller vertical pipes. The tubes contain the water to be evaporated and the steam, while the fire is outside them. It is essential that the larger tubes be horizontal, or nearly so, and that each of them be connected to the next tube by means of two of the connecting pipes. The boiler contains five layers of tubes of $2\frac{1}{4}$ ins. internal diameter and 3 ins. external; the connecting pipes are $\frac{7}{8}$ in. internal diameter and $1\frac{3}{8}$ ins. external. In working, the water level is in the middle layer of tubes, and it remains free from the violent undulations which occur frequently in boilers where the internal space is not divided off. It is probable that a circulation establishes itself in the water, which rises with the bubbles of steam through the vertical connecting pipe at one end of the tube, and descends by itself through that at the other. The hot gases from the fire pass backwards and forwards between the layers of tubes, and remain long enough in contact with them to allow of a very good absorption of the heat. A similar boiler, used for some time, had eight layers of tubes above the fire. The boiler is thus made up of a number of vertical subdivisions arranged side by side, each containing five to eight parallel tubes. The several sections are all connected together at the bottom by means of a cross tube, with connecting pipes to each section, through which the water finds the same level in all the sections. The steam is taken off through a similar cross tube at the top of the boiler, with a connecting pipe to the highest tube of each section. All the sections are proved with water pressure up to 3000 lbs. per square inch.

The boiler has about 12 square feet of grate surface, but the total area of the air spaces between the bars does not amount to more than is supplied by six square feet of ordinary grate surface; and accordingly the fire is large but slack. The total heating surface amounts to 882 square feet. The capacity is about 40 cubic feet, half of which is water space and half steam room. The whole boiler is firmly held together by cast iron girders, and encased in non-conducting sides and top, made of four thicknesses of light plate, riveted together and kept about $\frac{3}{4}$ inch apart by ferrules, so as to form three closed air chambers. This arrangement is specially adapted for marine boilers.

The flue from the boiler is made to pass through a box containing the three cylinders of the engine, passing first down the small or high pressure cylinder, then up the middle one, and finally acting on the low pressure cylinder. The temperature of the gases in this box varies from 400° to 500° Fahr. After leaving the box, they pass downwards through a vertical square flue 10 feet long, giving up their remaining heat to the feed water, which is forced up through a wrought

iron coil of $\frac{7}{8}$-inch pipe contained in the flue, having 200 square feet of heating surface. At the bottom of this flue the gases enter a vertical iron funnel of 40 feet high and 24 inches diameter. The heat is so completely abstracted by the feed water coil, that, after leaving it, the gases have never been found hotter than 100° Fahr.

This small quantity of heat in the chimney gave sufficient draft to cause the evaporation of $8\frac{1}{2}$ cubic feet of water per hour in the boiler; but by the aid of a small fan, driven by a belt from the main shaft of the engine, the evaporation was usually kept at 15 cubic feet per hour. The evaporating power of the boiler was tested by means of a water metre, and, in an experiment of five hours duration, 390 lbs. of anthracite coal evaporated 420 gallons of water, which is about $10\frac{3}{4}$ lbs. of water per lb. of coal.

The great strength of this construction of boiler is the result of its being, in reality, an aggregate of a number of very small boilers. It absorbs the heat from the fire with the facility of a moderate thickness of iron, $\frac{3}{4}$-inch, without ever having a calcareous lining to keep the water away from the hot metal; while, at high pressures, it is exposed to less strain than ordinary boilers at comparatively low pressures. Thus, the shell of a cylindrical boiler of 5 feet diameter, or 26 times the internal diameter of these tubes, will be exposed to 26 times as great a strain as the sides of the tubes when containing steam of the same pressure; or at 19 lbs. pressure, it will have as great a strain as the tubes at 500 lbs. But even if tubular boilers were made so thin as to be equally liable to give way with large boilers, they would still be much safer to use; for if one of the tubes were to be destroyed, the water from the neighboring tubes would be driven out through the small connecting pipes, by which it is in communication with the rest of the boiler, in a very quiet sort of way compared with that in which the contents of a large boiler are thrown out when one of its ends gives way, or its shell is rent open. In fact, explosions, in the ordinary sense of the word, are impossible with these tubular boilers. It is well known, that tubes are more effective and safe when containing the water and steam within them, than when containing the hot gases from the furnace and exposed to an external pressure of the surrounding steam, since the tenacity of wrought iron is greater than its stiffness. The tubular boilers also admit of being easily and speedily repaired, by taking out a defective section and replacing it by a fresh section, or by new tubes kept in store for such contingencies.

The engine, of which drawings were shown, is of 60 horse power, and works at a pressure of 500 lbs. per square inch. It consists of three single-acting cylinders of 12 ins. stroke, all attached to a single cross-head, with a connecting rod at each end to the crank shaft. The steam passes through the three cylinders successively, the down stroke being made by the simultaneous action of the first and third cylinders, and the up stroke by the action of the middle cylinder alone; so that the three attached to the same cross-head act, as regards the rotation of the shaft, like one cylinder.

The steam, after having expanded in the down stroke above the

piston of the first cylinder of 6 ins. diameter, is allowed by the lifting of a conical valve, to pass under the piston of the second cylinder of 15 ins. diameter, and at the same time under the piston of the first; so that during the up stroke or working stroke of the second piston, the piston of the first cylinder is in equilibrium, and the steam is expanding into the second cylinder of six times the area. The valve between these cylinders then closes, leaving open the passage between the bottoms of both, while the first cylinder is receiving a fresh supply of steam from the boiler through the steam valve. At the same time, the valve between the second and third cylinders is lifted, and the steam allowed to pass above the pistons of both these cylinders, leaving the second piston in equilibrium and driving the third piston down. In the down stroke, therefore, there is the same pressure of steam in the top of the third cylinder, in both ends of the second cylinder, and in the bottom of the first cylinder. The bottom of the third cylinder is constantly in communication with the vacuum of the condenser. The third cylinder is of the same diameter as the second, so that at the end of the down stroke, the steam has expanded to about twelve times the volume of the first cylinder. When the down stroke is completed, a conical exhaust valve allows the steam from the top of the third cylinder, and also from the top of the second, to escape into the surface condenser; whilst the valve between the second and third cylinders falls to its seat, closing the passage between the bottom of the second and the tops of both. The whole effect, therefore, of this arrangement, which works with great simplicity, is, that in the up stroke, the first and third pistons are in equilibrium, and the second piston has the vacuum on the top of it; and in the down stroke, the second piston is in equilibrium, and the first piston works against a back pressure equal to the pressure of the steam on the top of the third piston.

Indicator diagrams from the three cylinders were exhibited—that from the first cylinder being taken from the passage between the first and second cylinders, as there was not room for fixing the indicator on the small cover of the first cylinder.

When the steam in the first cylinder is allowed to expand to four times its original volume during the down stroke, it has expanded to seven times as much, or twenty-eight times its original volume, by the end of the up stroke of the second cylinder; and hence a considerable fall of temperature necessarily takes place in the steam, with a consequent abstraction of heat from the inside of the first cylinder, and also from the bottom of the second, which is still further cooled by the expansion of the steam in the third cylinder to forty-eight times its original volume. Not only are the two last cylinders cooled by contact with steam which has lost heat by great expansion, and is reduced to a temperature considerably lower than that at which it entered the first cylinder, but still more by the evaporation at low pressures of the water deposited at the beginning of the stroke, by the condensation of steam upon the cooled sides of the cylinders. That water is contained in the bottom of the second cylinder, was proved by inserting a screw

cock at the lowest part of the passage between the second and third cylinders; and another proof is given by the remarkable fact that the quantity of steam, calculated from the end of the indicator diagram of each successive cylinder, is $6\frac{3}{4}$ cubic feet from the first, $9\frac{1}{2}$ cubic feet from the second, and nearly 14 cubic feet from the third, showing that steam is condensed at the beginning of the stroke of the first and second cylinders, and subsequently evaporates into the next cylinder. The first and second cylinders together condense about half the steam,—a proportion which probably does not exceed the condensation of many condensing engines of far less expansion; yet, on account of the higher initial pressure of steam, the consumption of coal per horse power is only about $1\frac{1}{2}$ lbs. per hour.

The engine was made to run fast, in order to allow little time for evaporation of internal moisture in the cylinders, between the strokes; and, in all respects, gives the most favorable trial to the principle of great expansion from a high pressure through a succession of cylinders communicating directly with each other. In order to preserve from injury the cotton packing of the rod that lifts the steam valve of the first cylinder, which is exposed to steam of very high temperature, a horizontal cast iron tube, about 18 inches long, is fixed to the valve chest above the cylinder, containing a steel shaft, with a cam on its inner end, which lifts the valve. The shaft nearly fills the cast iron tube, and all escape of steam is prevented by a stuffing box, packed with cotton, at the outer end of the tube, which always remains cold, since there is no passage of steam through the tube. This plan of lifting the valve is found perfectly effective and convenient.

For constructing larger engines, to expand a greater number of times effectively, the arrangement that is most advantageous depends upon the initial pressure of steam. If steam is used at 500 lbs. initial pressure, it is thought best first to expand it down to about 125 lbs. pressure, in a couple of single-acting cylinders, connected, either on opposite cranks, or at opposite ends of a lever, so as to be equivalent in their action to one double-acting cylinder. The valves would be conical valves, lifted in the manner described above. From 125 lbs., the steam may then be expanded down further through a succession of double-acting cylinders with ordinary slide valves. But for most purposes, there is no doubt that sufficient economy of fuel can be attained by working at an initial pressure of 160 lbs., and by expanding the steam about 16 times, if it be done properly; and the appliances for this purpose are of the simplest kind, involving no novelty of construction, but merely of arrangement. It is submitted, that the mechanical and physical defects of all existing arrangements for getting more work than usual out of steam, by making it expand many times in one cylinder, may be avoided, and their object more fully carried out, by four common double-acting cylinders with simple slide valves. The cylinders would be of the same stroke, with areas in the proportion of 1, 2, 4, and 8, connected to four cranks on the same shaft, and with moderate sized tubular steam chambers, to dry and slightly superheat the steam between each cylinder. By making the first and

second cylinders work on opposite cranks, and close to each other, one would be pulling up while the other is pushing down, thus neutralizing the friction on the main journals. The third and fourth cylinders would likewise work on opposite cranks, set at right angles to the first pair, so as to distribute the power with uniformity throughout the whole revolution, the steam being cut off in each cylinder at two-thirds of the stroke. Each cylinder communicates with the next by means of a steam chamber, composed of drawn tubes connected together in the same manner as the tubes in the boiler already described, and placed in the flue from the boiler, for the purpose of superheating the steam to maintain the initial temperature throughout the whole expansion. Each steam chamber supplies steam to the next cylinder during the first part of the stroke, until the slide valve cuts it off, and allows the steam to expand during the remainder of the stroke; and, in each stroke, as much steam is supplied to the chamber, from the preceding cylinder, as goes out into the next cylinder. Thus, the supply of steam to the second cylinder being cut off at two-thirds of its stroke, which is also two-thirds of the exhaust stroke of the first cylinder, the remaining steam in the first cylinder and the intervening chamber is compressed into the chamber during the remaining third of the stroke, its pressure being thereby raised to the original pressure in that chamber, so that the next, and each succeeding stroke, of the second cylinder commences with the same pressure of steam. A similar process is carried out in the remaining cylinders and steam chambers.

When steam, in expanding through a succession of cylinders, with intervening steam chambers, leaves each cylinder at the same pressure as the steam in the chamber into which it passes, it necessarily gives theoretically the same gross work on the pistons as if it expanded to the same amount in a single cylinder. Practically, however, it is impossible to expand so much as 16 times in one cylinder, without introducing many serious evils, which bring down the power to a mere fraction of its theoretical amount: whereas the expansion of the steam to double its volume in one cylinder, can be carried out without difficulty or inconvenience.

The degree to which the steam will be superheated in the intermediate steam chambers depends on the temperature of the flue in which they are placed; but as the tubular boiler exposes a large extent of heating surface to the action of the hot gases from the fire, before they come in contact with the steam chambers, no inconvenient amount of superheating is likely to occur, nor any burning out of the chambers. It is desirable to arrange the superheaters, so that the hot gases may come in contact with them, in the same order in which the steam goes through them, so as to act last on the coolest steam chamber.

The surface condenser used with the engine above described consists of a number of straight wrought iron tubes, fixed vertically in a chamber, closed at the upper ends, and screwed by their open ends into a thick plate at the bottom. These tubes contain the cold water,

which circulates rapidly through them, and their outer surfaces are exposed to the steam to be condensed. Each of the tubes contains a smaller tube, open at both ends, and through this inner tube the condensing water is driven up by the pump to the top of the outer tube, and then descends through the annular space between the tubes. This arrangement prevents the possibility of any straining, and consequent leakage, of the tubes, from heating or unequal expansion, by having all the tubes fixed at one end only, with the other end left free. The condenser in use has about 20 square feet of cooling surface for every cubic foot of water condensed per hour, and the vacuum obtained by it varies from $26\frac{1}{2}$ to $28\frac{1}{2}$ inches of mercury, notwithstanding that the air pump is exceedingly small in proportion.

An incidental, but not unimportant advantage of using a surface condenser is, that it keeps the water level in the boiler constant, without any trouble to the engineer, by always returning to the boiler the exact quantity of water that has been taken out as steam. For circulating the water through the tubes of the condenser, the arrangement best suited for marine engines is a lift pump or air pump, to draw the sea water through them, with a screw cock on the inlet pipe, by which the supply of water can at pleasure be throttled; so that, even were a leakage to arise in the tubes of the condenser, no sea water could get in to mix with the distilled water, but, on the contrary, an outward leakage would occur, if care were taken to keep the vacuum inside the tubes a little better than that in the condenser. In order to supply the place of any distilled water that might escape by leakage or otherwise, a small still should be attached to the boiler, heated by means of a coil of steam pipe, of which one end communicates with the steam room of the boiler, whilst the other is over the hot well, and is provided with a screw cock. As soon as this cock is allowed to drip or run, the still will begin to work, and replenish the boiler with distilled water, through the usual channel of the condenser.

Mr. E. A. Cowper observed, that the advantages of high pressure steam were now generally acknowledged, and the pressure of steam in engines had been gradually raised, having risen now in locomotives from 100 lbs. to 150 and even 200 lbs. per square inch. He, therefore, thought it was desirable to look boldly at the advantages of a much higher pressure, as had been done in the paper just read, where it was proposed to work with 500 lbs. steam, and the engine described had been worked at that pressure, to show the advantages practically. The boiler he had seen working at that pressure, and it certainly appeared a very strong construction. With a high pressure of steam, he had long considered the use of a surface condenser and distilled water in the boiler essential to economy, and it was attended with advantages of great importance. The necessity for cleaning the boilers was done away with, as no deposit could ever be formed, and the water level was maintained constant, whatever quantity of steam was taken off by the engine, while there was only $\frac{1}{25}$th as much water to pump out of the condenser, and, what was even of greater importance, the pump-

ing out of the air, introduced with the injection water in ordinary condensers, was saved.

Mr. Perkins said, the indicator diagram, shown from the first cylinder, was taken from the passage between the valve and cylinder, because there was not room to get the indicator on the top of so small a cylinder. The boiler pressure was 570 lbs., and the spring of the indicator made the figure jump up to 600 lbs. when the steam was admitted, but the actual pressure was only 510 lbs. total at the time of cutting off. The steam was cut off at one-fourth of the stroke in the first cylinder, and expanded down to 170 lbs. total pressure, or about three times, when it was exhausted into the second cylinder, the pressure dropping to 88 lbs. total in the passage between the cylinders; from the second cylinder it was exhausted at 36 lbs., and dropped to 30 lbs. in the passage to the third cylinder, from which it was let out into the condenser at a pressure of 27 lbs. total, making the whole expansion from the commencement amount to about nineteen times.

Mr. E. A. Cowper remarked, that as the pipe from the cylinder to the indicator was long, there might be an accumulation of water in it, which would cause the indicator to jump by its momentum. He inquired whether the drop in the pressure, in exhausting from one cylinder into the next, was owing to the passage between the cylinders being large.

Mr. Perkins replied, that the passages were not large, but the drop was occasioned by the steam being cooled, from want of sufficient heat in the casing to maintain the temperature. The pipe from the cylinder to the indicator had to be made long, in order to keep the packing of the indicator from being burnt by the high temperature of the steam; consequently, the pressure was probably somewhat lower in the indicator than in the cylinder. The engine had not yet been applied to regular work, but had been working experimentally during the last six months with a friction break, to test the practicability of the plan. The cost was about the same as that of marine engines, namely, £50 to £60 per nominal horse power, including the boiler; the engine indicating, however, from $2\frac{1}{2}$ to 3 times the nominal horse power.

Mr. E. A. Cowper observed, that the larger engine suggested in the paper, with the steam expanded through four cylinders, working in pairs, on cranks at right angles, would give a very uniform driving power, with probably only from 10 to 25 per cent. variation in driving power throughout the revolution, according to the point of cutting off in each cylinder.

Mr. W. May had seen the engine at work, when it was driving the friction break, and it appeared a useful step towards improved economy in steam engines, by showing the practicability of much greater pressure and expansion, whether the details of construction at present adopted were considered the best or not. The boiler seemed in good order, and perfectly safe for the high pressure of steam. It could be easily repaired, by the removal of any portion, without interfering with the rest of the boiler. The temperature of the chimney

was remarkably low, the iron casing being so cool that the hand could be borne on it.

Mr. F. J. Bramwell had seen the engine at work, and considered it useful and interesting in illustrating the economy of steam power, by using increased pressure and greater expansion. The mode of estimating the evaporative duty of the boiler, by measuring the consumption of water with a metre, he thought was liable to error, if not checked by observing the total increase of heat in the condensing water, in order to allow for water carried over as priming, which otherwise made the evaporative results appear greater than they really were. It was necessary to adopt this check in calculating the evaporative duty, because priming was sure to occur, except in boilers with very large steam room, where there was no violent ebullition. He had known an instance where the boilers in some of the American steamers, made with a number of vertical tubes, had been stated to give a very high evaporative duty; but when their actual performance was tested with a metre, it was found that 43 lbs. of water were fed into the boiler per indicated horse power per hour, which certainly could never have been all converted into steam, but showed that priming must have taken place extensively, and that the apparent high evaporative duty was a mistake.

Proc. Mech. Eng. Soc., May 2, 1861.

On the Manufacture of Steel Rails and Armor Plates. By Mr. John Brown, of Sheffield, Eng.

From Newton's London Journal, February, 1862.

Steel Rails.—One of the most important items in the cost of railway maintenance is the renewal of rails, and it is therefore natural that much attention should have been paid to the various methods proposed for giving greater durability to the rail. Experience has shown the want of some means by which their duration could be prolonged; and in the manufacture of rails it is always now expected that the quality of the material and the method of piling shall be distinctly stated before any large amount of work is undertaken.

No ordinary material or method of piling or making the finished rail will, however, resist the crushing action of modern locomotives; and extraordinary means have been sought to accomplish this much desired object. Amongst the most important of the methods hitherto used for this purpose is that of forming the wearing surface of the rail entirely of steel, by introducing a bar of steel into the pile, and rolling it out so as to unite it with the iron body of the rail. Another method is to submit the surface of the ordinary iron rail to a process of conversion in a furnace specially adapted, thereby case-hardening the outer skin of the wearing portion of the rail. Both of these processes have many advocates, and to a certain extent they fulfil their object; still, they are open to the serious objection that only the crust or skin of the rail is rendered hard, and they do not prevent the body of the rail from yielding to the severe pressure of the wheels; lamina-

tion and splitting are only to a small extent diminished, and though the life of the rail is prolonged, the prolongation is uncertain. The same objections apply to the puddled steel rail, and it is also liable to vary considerably in its hardness, and to be at times too brittle for perfect safety. This liability to vary in quality is inseparable from the mode of manufacture as at present practised; and though many very good rails of this kind have been produced, the want of certainty in the manufacturing process seriously diminishes its value.

The introduction, however, of Bessemer's system has opened out a mode of producing a pure, homogeneous, hard, and tough material, most admirably suited for the manufacture of rails; and though their cost may for a time prevent their being extensively used, there is no doubt that on every railway there are certain places where they would be laid with economy, where the traffic is so constantly severe that ordinary points and crossings have to be renewed on an average four times a year. Once laid of cast steel rails, they would give no trouble for many years.

In the Bessemer process, the pig metal is reduced in a reverberatory furnace, and is then run by a trough into the blowing or converting vessel, in which air is forced through the fluid metal for about twenty minutes, or until the fluid pig is almost entirely decarbonized. A small quantity of melted pig containing a known proportion of carbon, is then added, and the charge of converted metal is then transferred to a ladle, from which it is poured into ingot moulds; not, however, by the usual mode of canting the ladle, but by opening a valve in the bottom of the ladle, which allows only the pure metal to run out into the moulds. The ingots are cast of such weight and form as are necessary for the production of each rail. Thus, for a 6-yard rail of 84 lbs. per yard, the ingot requires to be 9 inches square and 26 inches long. This ingot is hammered down to 6 inches square and 5 feet long, and then rolled in the ordinary way. It will be evident, that the only limit to the length of the rail made in this simple manner is either the weight of the ingot which can be produced, or the length of the rolling mill or heating furnace. It is as easy to produce long lengths as short ones; and in this respect the above method has some advantage over piling.

There is no tendency to lamination in this perfectly homogeneous material, and its toughness and ductility are remarkably shown by the specimens exhibited, all of which were twisted and bent when cold. Its tensile strength is upwards of 40 tons per square inch.

Cast steel rails are not an entire novelty; for several years ago a few were made at Ebbw Vale, and were laid at the bridge at the north end of the Derby station, and there they are at the present time perfectly sound and good, whilst the neighboring iron rails have been many times worn out and replaced. But these rails were made, at a great expense, from ingots cast in the old or usual method, and the imperfect appliances then existing made it impossible to introduce them commercially. Still, the experiment at Ebbw Vale has clearly proved the far greater power of resisting wear and tear possessed by

the steel rails; and now the method of producing ingots by the Bessemer process enables rails to be produced which bid fair to become in truth a really "permanent way."

Armor Plates.—In the further portion of the present paper, on the manufacture of armor plates, the writer's principal object is to elicit discussion upon this important subject; and as but a very short time has elapsed since the rival powers of the penetration of shot, and the resistance of plates, have been so seriously and energetically tested, it is necessary to speak with diffidence upon a matter which on all hands is allowed to be as yet imperfectly determined. No limit has yet been assigned to the magnitude of future artillery, nor has any degree of impenetrability of iron plates been declared unattainable. The manufacturer's business is simply to make the best and strongest armor which at the present time is wanted; his problem being how to produce the largest plate of iron of the maximum degree of toughness.

Two methods of producing large masses of wrought iron have been in use: the first by the process of building up under the steam hammer, and the second by building up under the rolls. Under the steam hammer, the plate is produced by welding together lumps or masses of scrap iron; each mass of scrap being added and welded to the end of the plate, until it reaches the required length. Plates made in this way have been seriously objected to on account of their brittleness; and it is reasonable to suppose that this mode of manufacture is somewhat likely to induce brittleness. There can hardly be any continuity of fibre in a plate forged from masses of scrap iron, perhaps of different qualities, each at different heats; the nature of the weld and its form, and the repeated cooling and re-heating of the plate, are also adverse to its possessing great toughness. The rolled plates have been found more uniform in quality and of greater toughness than the hammered; and though the difficulties in the manufacture are grave, there is no departure from the ordinary practice followed in making large plates for other purposes. The difficulties which do exist are chiefly due to the immense weight and size, and the intolerable heat of the mass, which must be dealt with while at a welding temperature.

The general size of the armor plates required for the plated frigates is from 15 ft. to 18 ft. long, from 2 ft. 6 ins. to 3 ft. 10 ins. wide, and $4\frac{1}{2}$ ins. thick. The weight, therefore, of the finished plate ranges from 60 to 110 cwts.; and in the unfinished state it comes from the rolls at 80 to 140 cwts. From 3 to 4 ins. is cut off the sides, and 10 or 12 ins. from each end; and in this item of waste, the hammering process has an advantage over the rolling.

The mode of manufacture of a 5-ton plate is as follows:—Bars of iron are rolled 12 ins. broad by 1 in. thick, and are sheared to 30 ins. long. Five of these bars are piled and rolled down to a rough slab. Five other bars are rolled down to another rough slab, and these two slabs are then welded and rolled down to a plate of $1\frac{1}{4}$ inches thick, which is sheared to 4 feet square. Four plates like this are then piled and rolled down to one plate of 8 feet by 4 feet, and $2\frac{1}{2}$ ins. thick; and lastly, four of these are piled and rolled to form the final entire plate.

There are thus welded up together 160 thicknesses of plate, each of which was originally 1 in. thick, to form the finished $4\frac{1}{2}$ ins., making a reduction of 35 times in thickness; and in this operation from 3500 to 4000 square feet of surface have to be perfectly welded by the process of rolling. It is not surprising that, even with the greatest care, blisters and imperfect welds should exist, and render the plate defective; this is the chief difficulty to be overcome, and a very serious one it is; and as the magnitude and weight of the plate increase, so does also the liability to failure.

The final operation of welding the four plates of 8 feet by 4 feet by $2\frac{1}{2}$ inches, is a very critical matter. To bring a pile of four plates of these dimensions up to a perfect welding heat all through the mass, without burning the edges and ends of the plates most exposed to the fire; to drag this pile out of the furnace, convey it to the rolls, and force it between them, in so short a time as to avoid its losing the welding heat, is a matter of greater difficulty than those unacquainted with the work would imagine. The intensity of the heat thrown off is almost unendurable, and the loss of a few moments in the conveyance of the pile from the furnace to the rolls is fatal to the success of the operation.

At the writer's works, the pile of four plates, which united form the finished plate, is heated in a special furnace, and is drawn out by a liberating chain on to an iron carriage, which conveys the pile to the rolls. The carriage travels upon a line of rails let into the ground; and close in front of the roll frame is a small incline upon the railway, which lifts up the front of the carriage at the moment of its arrival at the rolls, and enables it to deliver the pile upon the fore-plate. As the plate passes through the rolls, it is received on the other side upon a roller frame, which is set at a considerable elevation towards the rolls, so that the tendency of the plate is to return. The rolls are then reversed, and the plate, which was pressing against them, passes back through, and is received upon the carriage; and again the operation is repeated, until the 10 ins. thickness is reduced to $4\frac{1}{2}$ ins.

The plate is then lifted off the carriage by a crane, and deposited upon a massive cast iron straightening bed; and an iron cylinder, weighing 9 tons, is rolled over it to and fro by hand levers, until the curvature which the plate has acquired in the rolling, is entirely removed. As soon as the plate is sufficiently cool, it is lifted off the straightening bed by another crane, and laid upon a planing machine, where the final operation of planing its sides and ends are completed.

Mr. Brown exhibited specimens of the steel rails, fractured, to show the quality of the metal; and pieces of the rails that had been bent double while cold without fracture: also, a piece of 75 lbs. double-headed rail which had been drawn down hot into a bar 1 inch square, and then twisted cold without showing any tendency to cracking or splitting. In answer to a question of the Chairman, he said that they had been used hitherto mainly on the continent; those longest laid had been down about six or seven months at the new Pimlico Railway

Station in London, and had proved very satisfactory: they were in as good condition now as when first laid; and a set of steel points and crossings had also been in constant use for seven months at the same station. There were also some of the steel rails more recently laid on the Caledonian, Lancashire and Yorkshire, London and North-Western, and Rhymney Railways; but these had not yet been down long enough to afford any results as to their durability. The rails showed not the least brittleness, but were much tougher than wrought iron rails. The fractured rails exhibited were purposely broken at the time of rolling, to show the quality of metal: and its great toughness was proved by the rails exhibited, which were all bent and twisted cold. The cost of the rails was, of course, higher than that of ordinary rails, and was an objection against them on the English railways; but continental companies were willing to pay the extra first cost of a more expensive rail, provided it would wear better than the ordinary rails, and he believed the steel rails would wear out at least five ordinary rails; but none of the steel rails had been used up yet, and their durability could therefore only be estimated from their comparative appearance after a short time of wear. The price of the rails was £18 10*s.* per ton in England, and £5 or £6 more on the Continent.

Col. Kennedy inquired what reduction of weight it was considered could be safely made in the rails by the use of steel instead of the ordinary wrought iron rails.

Mr. Brown said, the weight was reduced about one-third as compared with ordinary wrought iron rails. The 75 lbs. double-headed steel rails had been tested up to 80 tons in the centre, with 3 feet length between the bearings, and the deflection was $2\frac{3}{4}$ or 3 ins., without showing any signs of cracking.

Mr. J. Fenton asked how the 80 tons load was applied, whether by hydraulic pressure or by dead weights, and how it was measured; with hydraulic pressure, it was sometimes difficult to ascertain the pressure correctly, in measuring by safety valves. He inquired also whether the ends of the rails were fixed in the bearings during testing.

Mr. Brown said the load was applied by hydraulic pressure, and measured by two safety valves—the valve of the press, and a separate valve on Mr. Naylor's plan, fixed on purposely for the experiment, to prevent any risk or mistake. The rails were simply supported on the bearings in testing, with the ends left free.

The Chairman inquired, in reference to the manufacture of the armor plates, what was the quantity of work that could be done in rolling the plates, and how many were produced per day in regular work.

Mr. Brown replied, that in ordinary work, with the one mill now in operation, three plates were turned out per day of 12 hours, weighing 5 or 6 tons each; if working all the 24 hours, 5 or perhaps 6 plates per day might be made, but this would require a second furnace for heating the plates, to allow of stopping and cleaning one furnace without delaying the work.

In answer to an inquiry of Col. Kennedy, as to what experiments

had been made on these armor plates, to determine their power of resisting shot, Mr. Brown remarked, that two armor plates, tried at Portsmouth in July, had proved, to a certain extent, successful. The plates were $4\frac{1}{2}$ inches thick, backed by 18 inches thickness of teak, and were fired at with shot 68 lbs. weight, from a 95 cwts. smooth-bore gun of 8 ins. bore, with 16 lbs. charge of powder, at 200 yards range. The first plate was 7 feet 9 ins. long by 3 feet 2 ins. wide: the first shot hit near a corner of the plate, at a place where the weld was imperfect, and indented the iron to some depth; the second shot also hit near the same place, and indented the plate; the third shot struck the plate in the centre, and made a hole right through the iron, making a crack all round the opening; the fourth shot hit near the bottom, and broke the lower edge of the plate in; and the fifth shot happened to go through the hole made by the third. The second plate was nearly double the length of the first, being 14 feet long by 3 feet 7 inches wide: the first shot indented the plate 3 inches, and broke out the iron at the centre of the indentation; the second shot punched right through, and broke the backing; and the third and fourth shots each broke out a hole of 12 ins. diameter, and smashed the backing. A portion, broken off one of the plates, was exhibited, which showed that the iron was much more fibrous than in the plates on which experiments had first been made, and still more favorable results were expected if the iron could be kept in a thoroughly fibrous state, so as to have a soft and tough quality, which was less easy to fracture than a hard and brittle metal.

Two of the armor plates were in the hands of the Admiralty for further experiments; and trials had been made at Shoeburyness of two of the plates 5 inches thick, which had proved altogether most satisfactory as to the tenacity and toughness of the plates. The object was, to produce armor plates capable of resisting guns of increased power; and the experiments now made seemed to show that this might be effectually accomplished by the mode of manufacture that had been described.

The Chairman observed, that the quality of the plate could be better judged of when it had been actually pierced in the experiments than when only indented, as they could then see the character of the hole, and examine minutely the completeness of welding of the several thicknesses. He inquired whether the Bessemer steel had been tried for the armor plates.

Mr. Brown had not yet tried it for the armor plates, but expected to do so shortly, when he had a hammer heavy enough for working it; he intended using a 4-ton Naylor's steam hammer, with the steam admitted above the top of the piston, in the fall, to increase the force of the blow.

The Chairman remarked, that he felt a great interest in the manufacture of the armor plates, as he was himself engaged, on the other hand, in endeavoring to increase the power of guns so as to penetrate the strongest plates that could be made. As regarded the mode of manufacturing the plates, he had seen and examined those which had

been fractured in the experiments, and his own observations at present were unfavorable to rolling the several thicknesses together to form the plates, as not giving pressure enough to insure a thorough welding in all parts. Moreover, the extent of surface to be welded, amounting to 3000 or 4000 square feet in the entire manufacture of a single plate, was so great, that it was difficult to conceive how a perfect weld could ever be obtained throughout, as it seemed impossible to insure an entire exclusion of dirt from between the plates, and unless they were kept quite clean, they could not be welded into a single homogeneous plate. The difference in resisting power was very great between a really homogeneous material and one having any lamination of structure; in the latter case, all portions of the material did not take their share of the strain in resisting a blow, but some were more severely strained than the rest, causing them to give way sooner; and a series of thinner plates, though making up a considerably greater total thickness, was inferior to a single homogeneous plate in resisting power. The very best plates he had seen at present were some small forged plates, worked under a hammer at Portsmouth Dockyard; these were thoroughly sound in all parts, and free from impurities. What was wanted for the armor plates was a perfectly homogeneous material, and of soft texture; if they could be made, like the steel rails that had been described, from a single mass of thoroughly homogeneous metal, he thought there might be a good prospect of success. Ordinary cast steel, however, he did not think would be so suitable as good wrought iron, on account of not being soft enough.

For forging the metal of the armor plates under the hammer, he considered the weight of the hammer was of the greatest importance; and in reference to the use of a 4-ton hammer, with steam above the piston to increase the blow, it had to be borne in mind, that the steam increased only the velocity of the blow without adding to the mass falling, which was not the result required; he feared the effect would be, that the force of the blow would be spent on the surface of the material, and would not go through to the centre of the mass like the blow of a heavier weight falling with a proportionately smaller velocity. This appeared to him a very important consideration in forging large masses, however effective that kind of steam hammer undoubtedly was for lighter work.

Proceedings Insti. Mech. Engineers, July 31, 1861.

Puddled Steel, Homogeneous Iron, and Steel Iron.

From the Lond. Civ. Eng. and Arch. Journal, February, 1862.

The question of the mechanical properties of puddled steel, as also the less highly carbonized products of iron, is one of growing importance. Cheap and ready manufacture and a high degree of strength are advantages claimed for this class of material, and its field of application is becoming largely extended. An accurate acquaintance with the limits of strength and laws of elasticity becomes therefore increasingly desirable.

We have before us a pamphlet by Mr. W. H. Barlow, F. R. S., M. I. C. E., giving an account of some experiments which he has conducted by permission of the Royal Arsenal at Woolwich, for the purpose of obtaining some reliable data upon this subject. The testing machine employed at Woolwich is a counterpart of that used by the United States Government for ascertaining the strength of cast iron. It records accurately the amounts of the ultimate resistances to rupture by tension, compression, transverse strain, and torsion, but is not well arranged for exhibiting the progressive action of the three first named kinds of strain. Consequently, as Mr. Barlow states, although the experiments may be relied on as far as they go, and point out the more important properties of the materials tested, they do not afford all the data that could be wished; as puddled steel rarely yields to rupture in the testing machine except under tension.

"Puddled steel is made direct from cast iron by a process analogous to that used in obtaining common wrought iron, but instead of expelling all the carbon, such an amount is left contained as to impart the quality of the steel to the metal so treated. Considerable experience is required in the selection of suitable qualities of metal, and also to know the precise moment at which to stop the process of decarbonization in the puddling furnace; and other conditions have to be observed in order to secure the success of the operation; but it is now accomplished with great certainty, and the result is the production at a very low cost of steel, which, although not of high quality, is nevertheless possessed of many valuable properties.

"In addition to the experiments on puddled steel, similar experiments were made on homogeneous metal and steel iron, and on puddled steel melted and cast into ingots. Steel iron is a condition of the metal when the process of decarbonization is carried further than in puddled steel; its fracture is fibrous, and it approaches very nearly to wrought iron. The other materials above mentioned show a crystalline fracture, the crystals being very small, fine, and regular, like that of gun metal. The steel possesses also similar properties of malleability, although much harder and of much greater strength than gun metal."

The following table (I.) is an abridgment of Mr. Barlow's summary of the experiments on tension:—

Table I.—*Summary of Experiments on the Resistance to Tension of Puddled Steel, &c.*

No. of experim't.	Name of Material.	Name of Maker.	Ultimate Strain per sq. inch.	Mean.	Remarks.
			lbs.	lbs.	
52 to 56	Puddled steel, . .	Mersey Iron Works,	84,152 to 109,117	95,233	Fracture crystalline.
19 " 23	Homogeneous metal,	Firth & Co., . .	88,640 " 115,133	100,994	" "
29 " 34	Puddled steel, . .	Naylor & Vickers,	100,931 " 133.054	116,336	" "
57 " 61	Puddled steel melted and cast into ingots,	Naylor & Vickers,	84,652 " 124,492	101,753	" "
8 " 12	Steel iron, . . .	Atlas Works, . .	67,487 " 71,158	69,456	" fibrous

From these results the author draws the following conclusions:—

"From the above experiments it appears that the ultimate tensile

strength of puddled steel, homogeneous metal, and puddled steel melted and cast into ingots, is nearly double that of wrought iron. The variation of strength in the different samples is not greater than is found to arise in wrought iron.

"Several specimens taken out and remeasured after receiving strain, indicate that permanent set first begins to be perceptible at 20,000 lbs. per square inch.

"Puddled steel and homogeneous metal broke with a fracture presenting a minute crystalline appearance; and there were two distinct forms of fracture, one being in a plane at right angles to the line of strain, and the other a cup-shaped fracture more or less perfect.

"The material called 'steel iron' showed a fibrous fracture, and was of much less strength than puddled steel and homogeneous metal. In this material it was evident that the process of decarbonization had been carried too far, and that it differed but little from iron of good quality."

From the summary of experiments on compression we extract the mean results (table II.):—

TABLE II.—*Summary of Experiments on the Resistance to Compression of Puddled Steel, &c.*

No. of experim't.	Name of Material.	Name of Maker.	Pressure per sq. in.	Amount of Compression.	Rate of Compression per ton per sq.in. in terms of length.
			lbs.	inch.	
47 to 51	Puddled steel (mean length, 1·323 ins.),	Mersey Iron W'ks,	21.908	·0032	·000247
35 " 38	Puddled steel (mean length, 1 368 ins.),	Naylor & Vickers,	20,196	·00325	·000263
24	Homogeneous metal (length, 1·295 ins),	Firth & Co.,	22,514	·003	·000231
62 to 65	Puddled steel melted and cast into ingots (mean length, 1·4175 ins.),	Naylor & Vickers,	21.998	·00575	·000413
13, 17, & 18,	Steel iron (mean length, 1·102 ins.),	Atlas Works,	23,574	·00533	·000459

"The samples tested were all about $1\frac{1}{3}$ inches in length. The approach of the steel pistons between which the samples were compressed was carefully measured, and the results as recorded are correct as showing the compressions of columns of the length employed. The amount of compression per ton per inch is however so great, and being moreover inconsistent with that which may be inferred from the experiments on transverse strain, it is to be presumed that the result is affected by the short length of the samples. The effect of the pressure is to enlarge the diameter at the centre of the sample.

Fig. 1.

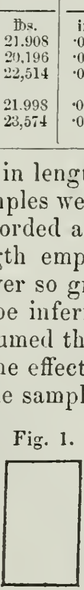
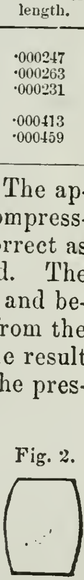


Fig. 2.



"Fig. 1 represents the sample No. 24 before pressure was applied, and fig. 2 is the same sample after receiving a pressure of 51 tons per inch, and similar effects, though in a less degree, result from smaller pressures. It is known that in long bars subjected to compression the centre portion is not proportionately expanded, and it follows that the decrease of length in short columns will not be proportional to that in long ones. It is evident, however, that the puddled steel and homogeneous metal are less compressible than cast puddled steel

and steel iron. Puddled steel, whether cast or otherwise, could not be crushed with any pressure the machine was capable of exerting; the only effect was to produce an alteration in the form of the sample. This property would indicate that if great pressure were to be resisted, it might be advantageous to submit the material to great compression before using it. The effect of the pressure appears to produce a re-arrangement of the particles, and when so re-arranged, they are capable of sustaining greater pressure than in their original form."

TABLE III.—*Summary of Experiments on the Resistance to Transverse Strain of Puddled Steel, &c.*

No. of experiment.	Description of Material.	Name of Maker.	Mean Breadth.	Mean Depth.	Deflection produced by 7500 lbs.	Value of E.*	Weight at which Deflection ceases to be regular.
			ins.	ins.	ins.		lbs.
39	Puddled steel,	Naylor and Vickers,	1·935	1·9275	·055		16,000
40	do.,	do.,	1·925	1·9600	·040		16,000
41	do.,	do.,	1·985	1·9750	·040		18,000
		Mean,	1·945	1·9542	·045	2,870,500	16,666
42	Homogeneous metal,	Firth & Co.,	1·955	1·960	·030		14,000
43	do.,	do.,	1·965	1·970	·060		14,000
44	do.,	do.,	1·960	1·980	·035		18,000
		Mean,	1·960	1·970	·042	2,979,200	15,333
2	Puddled steel,	Atlas Works,	2·110	2 085	·037		16,000
3	do.,	do.,	2 055	2·050	·042		16,000
		Mean,	2 082	2 062	·040	2,568,000	16,000
					Deflection produced by 5800 lbs.		
4	Puddled steel,	Atlas Works,	·975	1·985	·062		8,000
5	do.,	do.,	1·035	2 020	·055		9,000
		Mean,	1 005	2 002	·058	3,100,200	8,500
					Deflection produced by 2300 lbs.		
6	Puddled steel,	Atlas Works,	2·010	1·005	·065		3,500
7	do.,	do.,	1·975	·960	·083		3,500
		Mean,	1·992	·982	·074	2,838,000	3,500

*The value of E is obtained from the formula $E = \frac{l^3 w}{32 b d^3 s}$. [See "Barlow's Strength of Materials."]

"By comparing these experiments (Table III.) with those of Prof. Barlow on wrought iron bars 2 inches square (see Barlow on the Strength of Materials), it will be seen that the deflection under transverse strain is greater in puddled steel, when of like dimensions and under like circumstances, in the ratio of 10 to 11. But the weight it is capable of sustaining before the increments of deflection with equal weights cease to be regular is, as nearly as possible, double that of wrought iron. Hence, so far as these experiments go, it would appear that a bar of puddled steel may be bent about twice as much as a bar of iron of like dimensions, without impairing its elasticity, or without causing a greater permanent set."

In the above experiments the weight was applied at the centre in each case, and the distance between bearings was 20 inches.

Specific Gravity.

"The specific gravity was ascertained to be as follows:—

Puddled steel,	1st sample,	7·7805
" "	2d "	7·7836
Steel iron,	1st "	7·7431
" "	2d "	7·7580

Table IV.—*Resistance to Torsion.—Puddled Steel.*

Weight applied at 25 inches from centre.	Firth & Sons. Diameter. 1·763 inches.		Naylor & Vickers. Diameter, 1·864 inches.		Naylor & Vickers. Diameter, 1·861 inches.		Naylor & Vickers. Diameter, 1·876 inches.	
	Deflection.	Permanent set.	Deflection.	Permanent set.	Deflection.	Permanent set.	Deflection.	Permanent set.
lbs.	Deg.							
100	·25		·00		·00		·10	
200	·20		·25		·15		·40	
300	·50	s. 0	·50		·30		·30	
400	·59		·75		·40		·50	
500	·70	0	1·00	0	·45	·10	·60	·10
600	·75		1·00		·60		·70	
700	·85	·15	1·125	·25	·70		·80	
800	1·00		1·150		·70		·90	
900	1·20	R. S. ·20	1·25	·20	·90	·10	1·00	·20
1000	1·40		1·30		·90		1·20	
1100	1·60	30	1·40	·30	·90	S.	1·30	
1200			1·50		1·25		1·50	S.
1300			1·50	·30	3·55	R.S. 2 00	1·50	·30
1400			1·60				1·90	
1500	7·35		1·60	·40			2·00	
1600	8·85		1·95	R. S.			2·20	
1700	11·80		2·55	·90			2·30	·30
1800	15·50		3·10				2·50	
1900	19·40		4·15				Broke in putting on 1900 lbs.	
2000			5·60	3·00				

"The strength of puddled steel in resisting torsion will be best understood by a direct comparison between the results in the Table (IV.) and those obtained by Major Wade on samples of the same form and

dimensions in cast and wrought iron. The following Table (V.) is an abstract of such of his experiments as afford a direct comparison. In both sets of experiments the weight was applied at the end of a lever 25 inches long.

TABLE V.—*Table showing certain Results obtained by Major Wade on the Torsional Resistance of Cast and Wrought Iron.*

Description.	Weight applied, 1000 lbs.		Weight applied, 1500 lbs.		Remarks.
	Deflection.	Permanent set.	Deflection.	Permanent set.	
CAST IRON:—	°	°	°	°	
No. 1. 2d fusion,	2·2	0·2	5·9	2·2	Mean of four exper'ts.
" 3d "	1 7	0 0	3·0	0·3	One experiment.
10 parts No. 1 and 4 parts No. 3, 2d fusion,	1 5	0 0	2·4	0·1	"
8 parts No. 1 and 6 parts No. 3, 3d fusion,	1·5	0 0	2·3	0·1	"
Equal parts Nos. 1 and 2, 2d fusion,	1·9	0·1	3 8	0·9	Mean of two exper'ts.
" " 3d "	1·2	0·0	2 4	0·0	One experiment.
Mixture of 3 parts No. 1, 3 parts No. 2, and 2 parts No. 3. 2d fusion,	1 4	0 0	2·5	0·1	Mean of four exper'ts.
Mixture of 3 parts No. 1, 3 parts No. 2, and 2 parts No. 3, 3d fusion,	1·6	0·1	2·5	0·2	" "
WROUGHT IRON:—No. 1,		0 0	17 5	16·1	One experiment.
" No. 2,		0·1	16·6	15·4	"
" No. 3,		1·2	39·7	37·7	"

"Good puddled steel and homogeneous metal appear to be very similar in their mechanical properties; their tensile strength being nearly double that of wrought iron, the fracture being without fibre, and possessing a fine crystalline or granular appearance. Both materials are ductile, and may be condensed and consolidated under the hammer. Both materials also, although bending under transverse strain as much as wrought iron with equal weights, are capable of bearing nearly twice as much strain as wrought iron before producing a greater amount of permanent set.

"It is to be regretted that the testing machine in her Majesty's Arsenal at Woolwich is not adapted to receive bars of sufficient length for determining the modulus of elasticity. The very short length of the samples which the machine is capable of receiving in applying tensile and compressive strains, renders it impossible to arrive at correct conclusions from them in respect of the amount of extension and compression per ton per inch."

Mr. Barlow's experiments are an important contribution to our knowledge of puddled steel and the other materials tested. The ultimate strength under tension appears more uniform than might have been anticipated, which speaks well for the skill of the makers. We hope that, having gone thus far, Mr. Barlow may, on some future occasion, be enabled to ascertain by experiment the modulus of elasticity, and other data which still remain undetermined.

Method for Determining the amount of Sulphur in Pyrites.

From Newton's London Journal, Jan., 1862.

Dr. Crace Calvert stated, that he wished to draw the attention of the manufacturing chemists of this district to a very simple and rapid method which had been devised by the eminent chemist, M. Pelouze,

Master of the Paris Mint, for determining the amount of sulphur existing in pyrites. He (Dr. Calvert) was induced to do so, believing that any process which would simplify the long and troublesome operations now followed to ascertain the value of this mineral would be useful to many members now present at this meeting. The process consists in mixing intimately together one part of pyrites, thoroughly pulverized in an agate mortar, with five parts of carbonate of soda, seven parts of chlorate of potass, and five parts of chloride of sodium, and placing the whole in an iron spoon, which is gradually carried to a dull red heat. The mass, when cold, is first washed with cold water and then with boiling water, until the whole of the soluble matter is removed; and this solution is tested with a standard solution of sulphuric acid. As 100 grains of carbonate of soda requires 92·45 of monohydrated sulphuric acid, or $S\ O_3\ H\ O$, it follows, that the quantity of soda in the carbonate of soda employed, will decrease in proportion to the quantity of sulphur from the pyrites converted into sulphuric acid, which will have neutralized a corresponding quantity of the soda in the carbonate.

This mode of assaying is so simple, that the author states that he can determine, within 1 or 1½ per cent., the value of a sample of pyrites, in the space of an hour's time.

M. Pelouze also states, that by employing the following proportions of the same materials, the manufacturer can determine the amount of sulphur in burnt pyrites:—5 parts of the latter substance are mixed intimately with 5 parts of pure carbonate of soda, and 5 parts of chlorate of potash.

Proceedings Manchester Philosophical Society, Nov. 12, 1861.

Experiments on the Tensile Strength of Gun Metal. By William Fairbairn.

From the Lond. Mechanics' Magazine, October, 1861.

Sir—By the kind permission of Mr. Fairbairn, I am enabled to lay before the public the result of some experiments made by that gentleman upon the tensile strength of our gun metal, prepared from various descriptions of British iron. These experiments indicate that the Forest of Dean iron still retains its character of pre-eminent excellence beyond that of any other brand manufactured in the kingdom. The highest tensile strain has been obtained when No. 1 Cinderford grey pig iron was employed in the manufacture of the gun metal. This iron is manufactured at the Cinderford Iron Works, Forest of Dean, by Messrs. Allaway and Crawshay. Robert Mushet.

Coleford, Oct. 7, 1861.

Manchester, Sept. 13, 1861.

R. Mushet, Esq.,

Dear Sir—An opportunity has at length occurred of testing the specimens of gun metal which you forwarded some months ago. The results show an exceedingly high, indeed almost unprecedented, tena-

city. The whole of the specimens were reduced for a length of about 6 inches, to a diameter of 0·625 inches, or to a sectional area of 0·3068 square inches. Thus prepared, without having been heated or forged, they were placed in shackles, and their tensile strength ascertained by dead pressure.

Mark on Bar.	No.	Weight laid on in lbs.	Weight per square inch of section.		Elongation per unit of length.
			lbs.	tons.	
8	1	19·150			·000
	2	27·550			·020
	3	35·950			·037
	4	42·670	139·080	62·100	·078 broke.
5 B	1	19·150			·000
	2	27·550			·012
	3	35·950			·025
	4	44·350			·052
	5	45·865	149·490	66·738	·054 broke.
5 A	1	19·150			·002
	2	27 550			·007
	3	35 950			·019
	4	44 350			·030
	5	49 225	160·540	71·671	·030 broke.
D	1	19·150			·002
	2	27·550			·012
	3	35·950			·027
	4	40·990	133·610	59·645	·037 broke.
M	1	19·150			·005
	2	27·550			·015
	3	35·950	117·180	52·311	·021 broke.
N	1	19·150			·002
	2	27·550			·012
	3	35·950			·040
	4	41·380	136·340	60·867	·055 broke.
P	1	27·550			·019
	2	35·950			·040
	3	39 310	128·130	57·201	·126 broke.
R	1	19·150			·000
	2	27 550			·032
	3	33·430	108 970	48·645	·190 broke.
U	1	19·150			·003
	2	27·550			·015
	3	35·950			·030
	4	44·350	144 560	64·535	·077 broke.
4 Z	1	27·550			·007
	2	39·130			·022
	3	44·350			·032
	4	47·710	155·510	69·424	·055 broke.

Placing these results together in one table, we get the following summary:—

Iron.	Mark on Bar.	Breaking Weight per square inch.		Elongation per unit of length.
		lbs.	tons.	
	8	139·080	62·100	·078
Cleator, No. 2, .	5 B	149·490	66·738	·054
Cinderford, No. 1, .	5 A	160 540	71·671	·030
	D	133 610	59 645	·035
	M	117·180	52 311	·021
	N	136·340	60·867	·055
Swede iron, . .	P	128·130	57·201	·126
Old Park iron, .	R	108 970	48·645	·190
Cleator, No. 3, . .	U	144·560	64·535	·077
Cleator, No. 1, .	4 Z	155·510	69 424	·055
Mean, . .			61·314	·072

The metal indicated by its fracture that the structure of the various bars was different, in some approaching the bright granular fracture of steel, and the others being more iron grained, although the grain was very fine. The steely bars elongated least, and, generally, the bars having the highest tenacity, elongated least; but this rule is not without exceptions.

Rapid Transmission of Telegraphic Signals.

From the Lond. Mechanics' Magazine, October, 1861.

M. Guillemin has recently made some experiments at Paris with a Morse telegraph, similar to that shown at Manchester as M. Siemen's, to ascertain the greatest number of elementary signals (points and dashes), and consequently of words, that can be transmitted per minute over a single line of from 300 to 1000 kilometers in length. M. Guillemin employed, as manipulator, a small automatic transmitter, formed of four brass wheels, 25 centimeters in circumference, and carried upon the same axis. One small wheel produced the dots, another the dashes, and the two others discharged the wire after each signal. The plates which established the communications were wedge-shaped; four springs pressed the surface of the wheels, and the duration of their contact varied for the same uniform rapidity of rotation according as they were pushed from the broad sides towards the small sides of these trapezoidal plates. By this arrangement, the relation between the duration of the contact and the time which intervened between the successive contacts, was modified at pleasure. The transmitter carried only two words, France, Paris, which, in the Morse alphabet, are of about the medium length of French words. These two words were transmitted 30 times in a minute over a line of 570 kilometers in length, in fine weather. During a heavy rain, 40 words were easily transmitted per minute. Between Paris and Nancy, from

60 to 70 words were sent per minute. Over a line of 450 kilometers (the Havre line), words were sent at the rate of 75 per minute. This is about six times more rapid than is common among operators, who generally transmit from 10 to 15 words per minute. When only dots were sent, from 35 to 40 could be transmitted per second, which is at the rate of from 2100 to 2400 separate signals per minute.

For a single wire, the ratio of the duration of contacts to intervals which gives the most rapid transmission, varies according to the insulation of the line; it diminishes when the insulation is good, and increases when the escape is large. As this ratio, by means of M. Guillemin's apparatus, may be varied at pleasure, a great rapidity of transmission can always be attained. When the wire is well insulated, it is necessary to use wheels, which, after each discharge of the current, are placed in communication with the earth by the extremity which has touched the pile; without this precaution, all the elementary signals join together before a speed of 50 words per minute is attained. In certain cases, there is even an advantage in hastening the discharge of the wire, by means of a weak current in the opposite direction to that in which the signal is sent. When the insulation is defective, the discharging wheels are useless; but signals are sent less surely and less rapidly than in the first case. Besides, it is not necessary to discharge completely the wire between two elementary signals; that may even be injurious to the rapidity of transmission. It is necessary only to produce sensible variations in the intensity of the current which moves the electro-magnet of the receiver.

In conclusion, M. Guillemin states that great rapidity in the transmission of signals can only be obtained by means of an automatic manipulator, arranged so as to permit the operator to vary at pleasure the duration of the contacts, and the intervals which separate them, and so as to favor the discharge from the wire within proper limits.

Schneider's Electric Sounding Apparatus.

From the Lond. Mechanics' Mag., October, 1861.

It is stated in *Le Recueil Maritimé*, that experiments were made on the Lake Ladoga on June 11th, with Schneider's Electric Sounding Apparatus. The Russian steamer *Ladoga* has lately been employed in taking soundings in the lake of the same name, and M. Schneider was invited by the Russian Minister of Marine to test his invention. His apparatus consists of an electric battery using six elements. The sounding line was gutta-percha, (300 sajenes) 1800 feet in length, 2 lines in thickness, and covered. It contained two wires, one inside the gutta-percha, and one inside the outer covering. Bruck's sounding apparatus, slightly modified, was used. The weight of the leaden plummet was 12 lbs., but no portion of it was detached by contact with the bottom, as in Bruck's. The experiment commenced 6 miles east of the island of Valaam, and soundings were taken at different depths, varying from 156 ft. to 660 ft., and in each case both Bruck's sounding apparatus and Schneider's were used. At the moment the

latter touched the ground, the alarm clock attached to the apparatus was sounded by the electric current. Thirty-four soundings were made altogether, and in each case with the same results; the moment the plummet reached the bottom, although it was soft or muddy, the electric current sounded the alarm. The steamer *Ladoga* being of iron, M. Schneider made some experiments with only one of the wires, viz: that contained in the gutta-percha, thus making the iron vessel the upper metallic plate, and the sounding apparatus the lower metallic plate. The result was so satisfactory that a smaller and lighter line may be used, containing only one wire. After the experiments, M. Schneider's line was found to have lengthened 1 foot in 600, while the ordinary line was 4½ feet in 600 longer. M. Schneider's apparatus is said to be cheap and easily managed, and likely to be useful for deep-sea soundings.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 189.)

Solid Cylindrical Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formulæ. $W = 6{\cdot}71\frac{D^4}{L^2}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.
8	8	12	2·792	131·73	133·13
9	"	13·5	3·141	148·20	125·38
10	"	15	3·490	164·67	117·73
11	"	16·5	3 839	181·13	110·29
12	"	18	4·188	197·60	103·15
13	"	19·5	4·537	214·07	96·36
14	"	21	4·886	230·53	89·98
15	"	22·5	5·235	247·00	83·99
16	"	24	5·584	263·47	78·42
17	"	25·5	5·934	279·93	73·25

Solid Cylindrical Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 4{\cdot}79\frac{D^4}{L^2}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.
8	8	12	2·792	121·60	108·53
9	"	13·5	3·141	136·80	101·38
10	"	15	3·490	152·00	94 43
11	"	16·5	3·839	167·20	87·77
12	"	18	4·188	182·40	81·44
13	"	19·5	4·537	197·60	75·60
14	"	21	4·886	212·80	70·13
15	"	22·5	5·235	228·00	65·06
16	"	24	5·584	243·20	60·41
17	"	25 5	5·934	258·40	56·13

In Appleton's Dictionary of Mechanics, &c., vol. ii., p. 620, the following practical formula is given, by which to determine the amount of weight a solid cylindrical oak column will support, in lbs. :—

$$\frac{2470\,d^4}{4\,d^2 + \cdot 5\,l^2} = \text{w}.$$

Table showing the Weight Cylindrical Pillars of Oak will support, in lbs. and tons, deduced from the above formula.

Diam'ter in inches	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	1,162	823	598	449				
3	3,705	2,942	2,326	1,852				
4	7,711	6,586	5,546	4,649	3,903	3,293		
5	13,082	11,695	10,291	8,975	7.796	6,770	5,892	5.145
6	19,760	18,188	16,500	14,820	13,227	11.768	10,461	9,305
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	0·51	0·36	0·26	0·20				
3	1·65	1·31	1·03	0·82				
4	3·44	2·94	2·47	2·07	1·74	1·47		
5	5·84	5·22	4·59	4·00	3·48	3·02	2·63	2·29
6	8·82	8·11	7·36	6·61	5·90	5·25	4·67	4·15

Table showing the Weight that may be safely borne by Solid Cylindrical Pillars of Oak, deduced from Mr. Haswell's formula, in lbs. and tons,

$$\frac{2500\,d^4}{4\,d^2 + \cdot 5\,l^2} = \text{w}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	1,176	833	606	454				
3	3,750	2,977	2,354	1,875				
4	7,804	6,666	5,614	4,705	3,950	3,333		
5	13,241	11,837	10,416	9,084	7,891	6,853	5,963	5,208
6	20,000	18,409	16,701	15,000	13,388	11,911	10,588	9,418
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	0·52	0·37	0·27	0·20				
3	1·67	1·32	1·05	0·82				
4	3·48	2·97	2·50	2·10	1·76	1·48		
5	5·91	5·28	4·65	4·05	3·52	3·05	2·66	2·32
6	8·92	8·21	7·45	6·69	5·97	5·31	4·72	4·20

Table showing the Weight that Solid Cylindrical Pillars of English Oak will sustain with Safety, deduced from Mr. Tredgold's formula, in lbs. and tons,

$$\frac{2470\,d^4}{d^2 + \cdot 5\,l^2} = \text{w}.$$

Diameter in inches	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	1,796	1,097	731	520				
3	7,410	4,879	3,391	2,470				
4	18,597	13,173	9,580	7,185	5.546	4,391		
5	35,901	27,083	20,583	15,914	12,550	10,089	8,255	6,861
6	59,280	47,075	37,222	29,640	23,888	19,519	16,167	13,564
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	0·80	0·48	0·32	0·23				
3	3·30	2·17	1·51	1·10				
4	8·30	5·88	4·27	3·20	2·47	1·96		
5	16·02	12·09	9·18	7·10	5·60	4·50	3·68	3·06
6	26·46	21·01	16·61	13·23	10·66	8·71	7·21	6·05

Tables showing One-Tenth and One-Fourth of the Calculated Breaking Weight of Solid Cylindrical Pillars of Dantzic Oak, in Tons, as deduced from my calculations, given in preceding tables.

Table showing One-Tenth of the Breaking Weight.

Diameter in inches	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	0·29	0·16	0·10	0 07				
3	1 10	0·77	0 54	0·37				
4	2·57	1·96	1·49	1·16	0·87	0·67		
5	4·71	3·81	3·06	2·46	2·00	1·63	1·29	1·04
6	7 48	6·34	5·29	4·41	3·68	3·09	2·61	2·17
	Table showing One-Fourth of the Breaking Weight.							
2	0·72	0·41	0·26	0 18				
3	2·75	1 93	1·35	0 94				
4	6·44	4·90	3·74	2·90	2·19	1·67		
5	11·79	9·53	7·65	6·17	5·01	4·09	3·23	2·62
6	18·71	15·85	13·24	11·02	9·20	7·73	6·54	5·43

In the *Journal of the Franklin Institute*, vol. xli., pp. 246 and 247, Mr. Haswell gives the following. "To ascertain the Crushing Strength of a Solid Cylindrical Column of Cast Iron, $\frac{d^{3.6}}{l^{1.7}} \times 100{,}000 = \text{w}$. d representing the diameter of the column in inches, l, its length in feet, and w, the crushing weight.

"To ascertain the Crushing Strength of a Hollow Cylindrical Column of Cast Iron, $\frac{\text{D}^{3.6} - d^{3.6}}{l^{1.7}} \times 100{,}000 = \text{w}$. D representing the greater diameter.

"The above formulæ are those of Hodgkinson for the breaking or crushing weight. The formulæ of Euler, which are for the incipient breaking weight, are preferable, and are, with the alteration of the co-efficient, thus: $\frac{d^4}{l^2} \times 100{,}000 = \text{w}$, for solid cylinders, and $\frac{\text{D}^4 - d^4}{l^2} \times 100{,}000 = \text{w}$, for hollow cylinders.

"The above formulæ apply to all columns where the length is not less than about 30 times the external diameter."

One of the earliest writers on the strength of pillars was Euler. He published, first in Berlin Memoirs for 1757, and confirmed in the Petersburgh Commentaries for 1778, his theory that the strength of prismatic pillars is in the direct quadruplicate ratio of their diameters, and the inverse ratio of their lengths. His investigations were followed out by Poisson, who states, in his "*Mecanique*," that the formula for the strength of a cylindrical column is of this form: Resistance varies as $\frac{d^4}{l^2}$, where d is the diameter of the column, and l, its length.

Professor Moseley remarks, "For all the knowledge on this subject [the strength of pillars] on which any reliance can be placed by the engineer, he is indebted to experiment."

"The hypothesis upon which it has been customary to found the theoretical discussion of it, is obviously insufficient; and the results have been shown by Mr. Hodgkinson to be so little in accordance with those of practice, that the high sanction it has received from labors such as those of Euler, Lagrange, Poisson, and Navier, can no longer establish for it a claim to be admitted among the conclusions of science."

Table showing the Incipient Breaking Weight of Solid Cylindrical Pillars of Cast Iron, deduced from Mr. Haswell's formula, in lbs. and tons,

$$\frac{d^4}{l^2} \times 100,000 = w.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	44,000	25,000	16,000	11,111	8,163	6,250	4,938	4,000
3		126,562	80,000	56,250	41,326	31,640	25,000	20,250
4				177,777	130,612	100,000	79.012	64,000
5					318,877	244,140	192,901	156,250
6						506,250	400,000	324,000
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	19·64	11·16	7·14	4·96	3·64	2·79	2·20	1·78
3		56·50	35·71	25·11	18 44	14·12	11·16	9·04
4				79·36	58·30	44·64	35·27	28 57
5					142·35	108·99	86·11	69 75
6						226·00	178·57	144·64

Table showing the Breaking Weight of Solid Cylindrical Pillars of Cast Iron, deduced from Mr. Haswell's formula, in lbs. and tons,

$$\frac{d^{3.6}}{l^{1.7}} \times 100,000 = w.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	57,652	35,352	24,192	17,745	13,654	10.881	8,901	7,445
3		152,188	104,144	76.389	58,778	46,841	38,342	32.053
4				215,179	165,572	131,948	108,007	90,291
5					369,725	294,642	241,181	201,621
6						567,988	464,930	388,669
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	25·73	15·78	10·80	7·92	6·09	4 85	3·97	3·32
3		67·94	46·49	34·10	26 24	20·91	17·11	14·30
4				96·06	73·91	58·90	48·21	40·30
5					165 05	131·53	107·67	90·00
6						253·56	207·55	173·51

Table showing the Breaking Weight of Solid Cylindrical Pillars of Cast Iron, deduced from Mr. Hodgkinson's formula, in tons (applicable to pillars exceeding 24 diameters, as shown in preceding tables, and as below),

$$w = 44·16 \frac{D^{3·55}}{L^{1 7}}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	24·58	15·07	10·31	7 56	5·82	4·64	3·79	3·17
3		63·60	43·52	31 92	24·56	19·57	16·02	13·39
4			120·87	88 66	68 22	54·36	44·50	37·20
5				195 77	150·64	120 05	98·26	82·15
6					287·76	229·32	187·71	156 93

Abstract from Mr. Tredgold's table, entitled

"*A Table to show the Weight or Pressure a Cylindrical Pillar or Column of Cast Iron will Sustain with Safety, in hundredweights.*"

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.	Weight in cwts.
2	60	49	40	32	26	22	18	15
2½	105	91	77	65	55	47	40	34
3	163	145	128	111	97	84	73	64
3½	232	214	191	172	156	135	119	106
4	310	288	266	242	220	198	178	160
4½	400	379	354	327	301	275	251	229
6	592	573	550	525	497	469	440	413

Table showing the calculated weight from Mr. Tredgold's formula, in cwts. and tons,

$$\frac{9562\, d^4}{4\, d^2 + 18\, l^2} = \text{w}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
2	60·75	49·63	40·16	32·58	26·63	22·00	18 37	15·51
2½	105 93	91·31	77·55	65·49	55 32	46·91	40·01	34·37
3	162·78	145·51	128·06	111·67	97·00	84·25	73·31	64·02
3½	230·91	211·68	191·21	171·00	152 00	134 74	119·40	105·87
4	310·09	289·40	266 53	243 05	220·14	198 54	178·67	160·71
4½	400·18	378 39	353 62	327·42	301 07	275·48	251·27	228·81
5½	612·82	589·51	562 03	531·74	499 89	467·58	435·66	404·77
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	3·03	2·48	2 00	1·62	1·33	1·10	0·91	0·77
2½	5 29	4·56	3·87	3 27	2·76	2·34	2·00	1 71
3	8·13	7·27	6·40	5 58	4·85	4 21	3 66	3·20
3½	11·54	10 58	9 56	8·55	7·60	6·73	5·97	5 29
4	15·50	14·47	13·32	12·15	11·00	9·92	8·93	8·03
4½	20·00	18·91	17·68	16·37	15·05	13·77	12 56	11·44
5½	30·64	29·47	28·10	26·58	24·99	23·37	21·78	20·23

Abstract from Mr. Haswell's table, entitled

"*Table showing the Weight or Pressure a Column of Cast Iron will Sustain with Safety.*"

	Length or height in Feet.							
	6	8	10	12	14	16	18	20
Inch.								
2·5	12,285	10,647	9,009	7,605	6,435	5,499	4,680	3,978
3	19,071	16,965	14,976	12,987	11,349	9,828	8,541	7,488
3·5	27,144	25,038	22,347	20,124	18,252	15,975	13,923	12,402
4	36,270	33,696	31,122	28,314	25,740	23,166	20,826	18,720
4·5	46,800	44,343	41,418	38,259	35,217	32,175	29,367	26,793
6	69,264	67,041	64,350	61,425	58,149	54,873	51,480	48,321

Table showing the calculated weight from Mr. Haswell's formula, in pounds and tons,

$$\frac{10{,}000\, d^4}{4\, d^2 + \cdot 18\, l^2} = \text{W}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	7,117	5,813	4,705	3,816	3,120	2,577	2,152	1,818
2·5	12,408	10,696	9,084	7,671	6,480	5,495	4,688	4,027
3	19,067	17,045	15,000	13,081	11,363	9,868	8,587	7,500
3·5	27,048	24,795	22,397	20,029	17,805	15,782	13,982	12,401
4	36,322	33,898	31,219	28,469	25,785	23,255	20,928	18,823
4·5	46,875	44,321	41,420	38,352	35,265	32,268	29,433	26,801
5·5	71,780	69,050	65,831	62,283	58,552	54,767	51,029	47,412
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	3 17	2·59	2·10	1·70	1·39	1·15	0·96	0·81
2·5	5·53	4·77	4·05	3·42	2·89	2·45	2·09	1·79
3	8·51	7·60	6 69	5 83	5·07	4·40	3·83	3 34
3·5	12·07	11·06	9·99	8·94	7·94	7·04	6·24	5·53
4	16 21	15·13	13·93	12·70	11·51	10·38	9·34	8·40
4 5	20·92	19·78	18·49	17·12	15·74	14·40	13·13	11·96
5 5	32·04	30·82	29·38	27·80	26 13	24·44	22·77	21·16

Table showing One-Tenth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Flat Ends.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
2	2·45	1·50	1·03	0·75	0·58	0 46	0 37	0·31
2½	5 43	3·33	2·27	1·67	1·28	1·02	0·83	0 70
3	9 88	6·36	4·35	3·19	2 45	1·95	1·60	1·33
3½	15·86	10·99	7 52	5·51	4·24	3·38	2·77	2·31
4	23·65	17·03	12·08	8·86	6·82	5·43	4 45	3·72
4½	33·36	24·52	18·36	13·46	10·36	8·25	6·76	5·65
5½	58·83	44·84	34 93	27·46	21·12	16·83	13·78	11·52

Table showing One-Fourth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Rounded Ends.

2	2·39	1·47	1·00	0·73	0·56	0·45	0·37	0·30
2½	5 54	3·40	2 32	1·70	1·31	1·04	0·85	0·71
3	11·02	6 75	4·62	3·39	2·60	2·07	1·70	1·42
3½	19 67	12·06	8·25	6·05	4·66	3·71	3·04	2 54
4	32·50	19·93	13 64	10·00	7·69	6·13	5·02	4·19
4½	50·12	31·04	21·24	15·58	11·98	9·55	7 82	6·53
5½	96·12	66·01	45·17	33·13	25·49	20·31	16·63	13·90

Table showing One-Fourth of the Calculated Breaking Weight, in Tons. as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Flat Ends.

2	6·14	3·76	2·57	1·89	1·45	1·16	0 94	0·79
2½	13·58	8·32	5 69	4·17	3·21	2·56	2·09	1·75
3	24·70	15·90	10·88	7·98	6·14	4 89	4·00	3·34
3½	39·65	27·48	18·81	13·79	10·61	8·46	6·92	5·78
4	59·13	42·58	30·21	22·16	17·05	13 59	11·12	9·30
4½	83·41	61·30	45·90	33 67	25 90	20 64	16·90	14·12
5½	147·09	112·11	87·34	68 65	52 82	42 09	34·45	28·80

Table comparing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron, having Both Ends Rounded or Irregularly Fixed, with Pillars of the same dimensions, having Both Ends Flat and Firmly Fixed: deduced from Mr. Hodgkinson's formulæ, as given in preceding tables.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Rounded Ends or Irregularly Fixed. Calculated breaking weight per sq. inch in tons from the index			Flat Ends and Firmly Fixed. Calculated breaking weight per sq. inch in tons from the index			Mean ratio of strength.
			3·6.	3·76.	Mean strength per sq. inch in tons.	3·55.	3·6.	Mean strength per sq. inch in tons.	
2	2	12	15·92	17·13	16·52	28·39	28·81	28·60	1·73
3	"	18	8·88	9·92	9·40	20·03	20·44	20·23	2·15
4	"	24	5·44	6·08	5·76	14·59	14·95	14·77	2·56
5	"	30	3·72	4·16	3·94	10·66	11·04	10·85	2·75
8	"	48	1·67	1·87	1·77	4·79	4·96	4·87	2·75
14	"	84	0·64	0·72	0·68	1·85	1·91	1·88	2·76
20	"	120	0·35	0·39	0·37	1·00	1·04	1·02	2·75
2	3	8	23·49	25·65	24·57	35·33	35·86	35·59	1·44
3	"	12	15·49	17·41	16·45	27·67	28·33	28·00	1·70
4	"	16	10·42	12·37	11·39	21·71	22·37	22·04	1·93
5	"	20	7·13	8·50	7·81	17·27	17·89	17·58	2·25
8	"	32	3·20	3·82	3·51	8·99	9·50	9·24	2·63
14	"	56	1·23	1·47	1·35	3·47	3·67	3·57	2·64
20	"	80	0·67	0·80	0·73	1·89	2·00	1·94	2·65
2	4	6	29·08	31·63	30·35	39·27	39·80	39·53	1·29
4	"	12	15·19	17·60	16·39	27·07	27·98	27·52	1·67
6	"	18	8·28	10·34	9·31	18·82	19·63	19·22	2·06
8	"	24	5·08	6·34	5·71	13·55	14·24	13·89	2·43
10	"	30	3·47	4·34	3·90	9·61	10·30	9·95	2·52
14	"	42	1·96	2·45	2·20	5·42	5·81	5·61	2·55
20	"	60	1·07	1·33	1·20	2·96	3·17	3·06	2·55
2	5	4·8	33·12	35·75	34·43	41·69	42·17	41·93	1·21
4	"	9·6	19·16	22·23	20·69	31·22	32·12	31·67	1·53
6	"	14·4	11·84	14·28	13·06	22·95	23·94	23·44	1·79
8	"	19·2	7·26	9·39	8·32	17·19	18·10	17·64	2·12
10	"	24	4·97	6·43	5·70	13·23	14·02	13·62	2·38
12	"	28·8	3·64	4·71	4·17	9·97	10·80	10·38	2·48
14	"	33·6	2·80	3·62	3·21	7·67	8·31	7·99	2·48
16	"	38·4	2·23	2·89	2·56	6·11	6·62	6·36	2·48
18	"	43·2	1·82	2·36	2·09	5·00	5·42	5·21	2·49
20	"	48	1·52	1·97	1·74	4·18	4·53	4·35	2·50
2	6	4	36·08	38·62	37·35	43·28	43·71	43·49	1·16
4	"	8	22·65	26·15	24·40	34·28	35·18	34·73	1·42
6	"	12	14·77	17·88	16·32	26·41	27·49	26·95	1·65
8	"	16	9·72	12·77	11·24	20·46	21·53	20·99	1·86
10	"	20	6·65	8·86	7·75	16·12	17·11	16·61	2·14
12	"	24	4·88	6·50	5·69	12·94	13·84	13·39	2·35
14	"	28	3·75	5·00	4·37	10·17	11·13	10·65	2·43
16	"	32	2·99	3·98	3·48	8·11	8·87	8·49	2·43
18	"	36	2·44	3·26	2·85	6·63	7·26	6·94	2·43
20	"	40	2·04	2·72	2·38	5·55	6·07	5·81	2·44
12	7	20·57	6·24	8·52	7·38	15·37	16·41	15·89	2·15
16	"	27·42	3·83	5·22	4·52	10·29	11·35	10·82	2·39
20	"	34·28	2·62	3·57	3·09	7·04	7·76	7·40	2·39
12	8	18	7·73	10·78	9·25	17·63	18·82	18·22	1·96
16	"	24	4·74	6·61	5·67	12·56	13·55	13·05	2·30
20	"	30	3·24	4·52	3·88	8·66	9·61	9·13	2·35
12	9	16	9·33	13·00	11·16	19·74	21·04	20·39	1·82
16	"	21·33	5·72	8·13	6·92	14·34	15·47	14·90	2·15
20	"	26·66	3·91	5·56	4·73	10·40	11·61	11·00	2·32
16	10	19·2	6·77	9·79	8·28	16·05	17·31	16·68	2·01
20	"	24	4·63	6·70	5·66	12·25	13·33	12·79	2·25
16	11	17·45	7·89	11·58	9·73	17·68	19·06	18·37	1·88
20	"	21·81	5·40	7·92	6·66	13·65	14·86	14·25	2·13
16	12	16	9·07	13·16	11·11	19·23	20·70	19·96	1·79
20	"	20	6·20	9·24	7·72	15·02	16·34	15·68	2·03

The following table shows the strength of hollow uniform cylindrical pillars of cast iron, in ordinary use for mill purposes, warehouses, and other large structures. I have computed the strength by three of Mr. Hodgkinson's formulæ, as given by him for pillars with flat ends and firmly fixed, both for the breaking weight of the pillars, and per square inch of section; also, for similar pillars, having rounded ends or irregularly fixed, by three other of his formulæ.

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight of pillar in tons from formulæ,		
				$W = 44{\cdot}34\,\frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.	$W = 44{\cdot}3\,\frac{D^{3\cdot6} - d^{3\cdot6}}{L^{1\cdot7}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.	$W = 42{\cdot}347\,\frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.
6	8	6	9	784·94	807·97	777·89
7·5	"	"	11·25	697·52	721·38	693·32
8	"	"	12	670·11	697 86	666·94
9	"	"	13·5	618 28	647·30	617·17
10	"	"	15	570 58	600·28	571·42
10·5	"	"	15·75	548·27	578·14	550·03
11	"	"	16·5	526·97	556·91	529·60
11·5	"	"	17·25	506 65	536 55	510·11
12	"	"	18	487·28	517·07	491·52
12·5	"	"	18·75	468·82	498·44	473·79
14	"	"	21	418·58	447·35	425·44
16	"	"	24	362·14	389·33	370 86
18	"	"	27	315·68	341·04	325 65
20	"	"	30	277·22	300·72	288·00
				$W = 44{\cdot}34\,\frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$	$W = 44{\cdot}3\,\frac{D^{3\cdot6} - d^{3\cdot6}}{L^{1\cdot7}}$.	$W = 42{\cdot}347\,\frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$.
22	"	"	33	238 08	266·05	252·37
24	"	"	36	205·35	229·47	219·00
26	"	"	39	179 22	200·28	192·21
28	"	"	42	158·01	176·57	170·34
30	"	"	45	140·52	157·03	152·22
				Calculated breaking weight per square inch of section from the above formulæ, in tons.		
6	8	6	9	35 69	36·74	35·37
7·5	"	"	11 25	31·71	32·93	31·52
8	"	"	12	30·47	31·73	30 32
9	"	"	13·5	28·11	29·43	28 06
10	"	"	15	25·94	27·29	25·97
10·5	"	"	15 75	24·93	26·28	25·01
11	"	"	16·5	23 96	25 32	24·08
11·5	"	"	17·25	23·03	24·39	23·19
12	"	"	18	22·15	23·51	22·35
12·5	"	"	18·75	21·31	22·66	21·54
14	"	"	21	19·03	20·34	19·34
16	"	"	24	16·46	17·70	16·86
18	"	"	27	14·35	15·50	14·80
20	"	"	30	12·60	13·67	13·09
22	"	"	33	10·82	12·09	11·47
24	"	"	36	9 33	10·43	9·95
26	"	"	39	8·14	9·10	8·74
28	"	"	42	7·18	8·16	7·74
30	"	"	45	6·38	7·14	6·92

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight of pillar in tons from formulæ,		
				$W = 13 \frac{D^{3.6} - d^{3.6}}{L^{1.7}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.	$W = 13 \frac{D^{3.76} - d^{3.76}}{L^{1.7}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.	$W = 14{\cdot}78 \frac{D^{3.6} - d^{3.6}}{L^{1.7}}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$.
6	8	6	9	504·25	600·16	538·78
7·5	"	"	11·25	404·88	498·31	437·79
9	"	"	13·5	330 02	416·88	360·11
10·5	"	"	15·75	273 23	352·19	300·22
12	"	"	18		300·62	
				$W = 13 \frac{D^{3.6} - d^{3.6}}{L^{1.7}}$.	$W = 13 \frac{D^{3.76} - d^{3.76}}{L^{1.7}}$.	$W = 14{\cdot}78 \frac{D^{3.6} - d^{3.6}}{L^{1.7}}$.
12	"	"	18	218·79		248·75
14	"	"	21	168·35	240·62	191·40
16	"	"	24	134·16	191 75	152·53
18	"	"	27	109 82	156·96	124·85
20	"	"	30	91·80	131·21	104·37
22	"	"	33	78·07	111·59	88·76
24	"	"	36	67·34	96·25	76 56
26	"	"	39	58·77	84·00	66·82
28	"	"	42	51 81	74·06	58·91
30	"	"	45	46·08	65·86	52·39
				Calculated breaking weight per square inch of section from the above formulæ, in tons.		
6	8	"	9	22·92	27·29	24·49
7·5	"	"	11·25	18·41	22·65	19·90
9	"	"	13·5	15·00	18·95	16·37
10·5	"	"	15·75	12·42	16·01	13·65
12	"	"	18	9 94	13·67	11·31
14	"	"	21	7·65	10·94	8 70
16	"	"	24	6·10	8·71	6·93
18	"	"	27	4·99	7·13	5 67
20	"	"	30	4·17	5·96	4·74
22	"	"	33	3 55	5·07	4·03
24	"	"	36	3·06	4·37	3 48
26	"	"	39	2·67	3·81	3·03
28	"	"	42	2·35	3·36	2·67
30	"	"	45	2·09	2·99	2·38

I have been unable to complete the above table in time for the press for this month's number; it will therefore be given in a future number, along with tables which I have computed for the Strength of Hollow Pillars, similar to those which were employed in the construction of the Pemberton Mill, Lawrence, Mass., and the pillar referred to in evidence before the coroner's jury; and, in connexion with the tables, it may not be out of place to give some extracts, as obtained from various sources.

(To be Continued.)

The Annealing Temperatures of Metals and Crystallization produced by Vibration.

From the Lond. Practical Mechanics' Journal, January, 1862.

Few examples, numerous as these are in all directions, more strongly indicate the intimate and important, although far from superficially obvious, relations, that subsist between the higher physics and the most common and humble practical arts, than do those which concern the molecular properties of the applied metals under the various conditions to which practical uses subject them. Upon two classes of molecular change in metals we propose to offer some remarks, on both of which much remains to be known.

The construction and the safety of the millions of railway wheels that carry men and merchandise over the civilized globe, (with the small exception of the untyred wheels used in North America,) and of all the future ordnance of the world—for towards built-up guns it all assuredly tends—alike depend upon the "shrinking on hot" of one ring of metal over another.

The *amount* of shrinkage, the degree of coercive radial compression produced by the ring or tyre, and the co-ordinate tension suffered by the latter, are all important to be known, or determinable beforehand, and this knowledge demands our acquaintance with certain molecular changes induced in metals (and more especially in iron and steel) by alterations of temperature which, up to the present moment, are almost wholly unknown. The result is, that the "tyreing of wheels" is, we may say, altogether a matter of "rule of thumb," and the shrinking on upon each other of the successive plies of rings of built-up guns, such as "the Armstrong," equally one of "trial and error," and in every individual piece "shrunk on," one of danger and uncertainty in result at the best.

The effects of such empirical practice as respects wheels were rendered terribly apparent during the last severe winter upon nearly all our great lines of railway. The mere dropping of our winter cold a few degrees below the average temperature of our climate produced day after day (and worst of all at night, when the temperature was a minimum) the bursting of innumerable tyres, attended with loss of life and property, and with obstructed railways, until at length the danger became so great that the speed even of our mail trains was, with the consent of government, temporarily reduced upon most of our great lines of communication.

Another winter has come, which possibly may be as severe, yet our engine and carriage, and truck wheels, remain just as they were, with the exception of some inventions, patent or otherwise, proposing to "get into the rere" of the difficulty by abandoning shrunk on tyres altogether, a thing not likely for general adoption—in fact, impossible to be adopted at once, if ever so perfect, and leaving out of view the huge existing stock of wheels that must be worn out, safe or unsafe.

Nothing has been done in the only true direction, namely, that

which shall enable us to know what we are about when we "shrink on a tyre."

We are not now going to write either about the constructive form or parts of wheels or detail of railway wheel making, still less about "building up" cannon; but we mean to offer some remarks upon what lies at the foundation of both, coupled also with some upon a closely allied set of molecular conditions, upon which the safety and durability in service, both of wheels and of guns, has been assumed greatly to depend. Our object is to direct the attention of our physical philosophers and educated engineers to our ignorance, and, while we ask these "light bearers" to illuminate us practical men in the directions in which we want light, to suggest, in part, the means by which science may hope to attain it.

When a cylindric iron ring, like a wheel tyre or gun segment, which just fits a solid cylinder on which it is placed, is reduced in temperature, and, therefore, diminished in length, it has been long assumed by writers on physics that, for each depression of 15° of Fahrenheit's scale nearly, a diminution of length will take place equal to about $\frac{1}{10000}$ of its length; and as the extension of a bar of wrought iron of mean quality is about the same, when extended by a force equivalent to one ton per square inch, so the tangential tension or grip of the ring is said to equal a ton per inch of section for each 15° Fahrenheit lowering of temperature.

This is, *in no case, strictly true*, though, within the limits of a few hundred degrees above or below a temperate atmosphere (say 50 Fah.), it may approximate to fact.

At much higher temperatures, however, what happens? Take the case of a railway tyre shrunk on the wheel it has been fitted to, at some temperature between black redness and bright redness. Here two new phenomena come into play. The metal, heated until its molecular condition is altered, and more or less of its rigidity gone, and replaced by a new state of ductility and softness, amounting in the higher extremes almost to plasticity, *is no longer in a condition to transmit the force* of its own contraction, and the latter is expended, not in laboring force at any point of the circumference, but in work done within the particles of the bar, in altering its form and *increasing* its length permanently, and the final effort of the lost heat, expended in "grip," is only the *residual strain*, or difference between the total force of contraction due to the entire heat laid up in the applied ring, and that already expended in permanent alteration of form. The ratio between these two portions of the total force of the heat varies, as the ring is shrunk on at a lower or higher temperature, in virtue of the facts chiefly ascertained by the Franklin Institute, bearing upon the loss of ultimate passive resistance to tension, produced in iron by continuous elevation of temperature. Thus, at 900° Fahrenheit, the resistance to tension is reduced in round numbers $\frac{1}{4}$th, at 1050° $\frac{1}{2}$, at 1240° $\frac{2}{3}$ds, at 1317° $\frac{7}{10}$ths, and at 3945° Fahrenheit, the fusing point, it of course becomes zero. So that, if we take the average resistance to rupture at common temperatures of a wheel tyre to be 24 tons to

the inch of section, and shrink it on at different higher temperatures, the succeeding table will show the proportion in which the total force of contraction is divided between grip and elongation of the ring.

Temperature.	As known by workmen.	Effort of Contraction per square inch.	Effort of Elongation per square inch.
900° Fah.	Black Red.	18 tons.	6 tons.
1050° "	Low Red.	12 "	12 "
1240° "	Bright Red.	8 "	16 "
1317° "	Yellow.	7 "	17 "
3945° "	White.	0 "	0 "

It follows that, *cæteris paribus*, the grip depends not only upon the lowest temperature to which the ring is exposed, but also upon the highest temperature at which it is shrunk on. But, besides the continual though not equable reductions in tenacity due to increase of temperature, another molecular condition comes into play, in "shrinking on hot," which, at a certain though unknown point of elevation, produces an abrupt, permanent, and often large reduction in the tensile strength of the iron, as well as alteration in the preceding relations.

At a determinate, though as yet undetermined temperature, the iron becomes *annealed*. The arrangement of its particles, as induced by rolling, &c. (to still confine ourselves to the illustration of the tyre) is altered again when heated to a *certain* point; their relative distances are increased, as evidenced by diminished specific gravity, and the tensile strength at the same moment greatly decreased. Salient examples of this are familiar in brass or steel pianoforte wire: as these come hard and elastic from the draw plate, the former has a tensile resistance of 87,000 lbs. per square inch (nearly that of wrought iron), and the latter of 120,000 lbs. per square inch, or even more. In this state either metallic wire coiled round a cylinder (such as one of the wire-wrapped guns proposed by Mr. Longridge) would transmit in "grip" very nearly the whole tension due to its reduction in length for each thermometric degree. But let the brass wire be heated to something above a red heat in daylight, and the steel wire to a still more elevated temperature (a yellow heat in daylight at the very least), and the ultimate tenacity of each is found enormously and suddenly reduced. The brass wire will now tear asunder at 17,000 or 18,000 lbs. per square inch, and the steel at 70,000 to 80,000. Both, however, elongate greatly more than before, so that it is probable that the co-efficient (*of Poncelet*), that is to say, *the foot pounds expended in the work of rupture*, is the same before and after annealing; but inasmuch as the "grip" in any given case greatly depends upon the relation between the range of elongation by tension, and the final resistance to rupture—in other words, upon the ratio between the two factors, of which the above co-efficient is made up, so without a knowledge of the precise temperature at which this sudden molecular change

called annealing takes place, our operations of shrinking on must, in this second respect, remain but tentative and unsatisfactory.

Now the fact is, that the "annealing temperature" has not been yet ascertained for any one metal, and all that is known about it is, that there is a fixed and rather narrow range of elevated temperature peculiar to each metal, without the limits of which, annealing does not take place, and that the absolute mean temperature for each metal seems to be greater in some proportion as the fusing temperature of the metal itself is higher. Platina, for instance, when hard from wire-drawing or lamination, is not annealed under an intense white heat; wrought iron at about a bright red; in some sorts, not before a yellow heat; copper, at a low cherry red; and when we come down to the metals of very ready fusibility, such as tin and lead, their annealing temperature appears to be so low that the *heat evolved* in them by conversion of mechanical force, in laminating or wire-drawing is sufficient to keep them annealed, *i. e.*, they *cannot be hardened* by such processes. It is this curious fact of molecular physics which affords the explanation of the circumstance well known to those engaged in the trades of rolling sheet lead, or "drawing" lead pipes by the older methods, namely, that the rolling or drawing can be accomplished by a *less total expenditure of power* if performed fast than much more slowly. That is to say, the power demanded is a minimum when the pressure is sufficiently sharp to evolve the heat of annealing in the lead. Upon a like condition (with others not here in question) depends the curious process of forcing up in pure tin the patent collapsible vessels of Rand now so extensively in use for receptacles of oil colors, perfumes, &c.

Baudrimont, a French chemist and physician, has published some most important researches (so far as they go) on annealing temperatures, which may be found in *Ann. de Chim. et Phys.*, tom. ix.; but as respects the *precise* temperature at which annealing takes place, he has only shown, that within certain not very wide limits annealing may be produced if the temperature be long continued; but that there is one point at the highest end of the scale at which annealing takes place instantaneously. To ascertain this point rigidly for all our more important metals would be most desirable, and we would offer to the physical experimentalist some hints as to a method by which probably the investigation might be advantageously pursued.

It has been proved by Magnus (*Ann. de Chim. et Phys.*, tom. xxxiv. 3 *ser.*) and verified by others, that no thermo-electric current can be produced by the heating of any part of a metallic wire, the whole length of which is in the same molecular condition, and its whole surface in the same state, *i. e.*, all polished and free from oxide, &c.

Magnus further ascertained that when one portion of the length of wire was *hard* as it came from the draw plate, and another portion of it had been previously *annealed*, that then, when heat was applied at the point of junction of these respective portions, a thermo-electric current was produced, and gave large deflections with the galvanome-

ter; and that the production of the current was due to a difference in molecular arrangement in the hard and in the annealed portions, and not merely to a difference in their conductivity of *heat.* This he ascertained by showing that annealed and unannealed wire were in this respect the same.

If, then, we arrange a metallic wire or bar, having segments as above, one portion hard, the other annealed, so that it shall pass through a gas flame or furnace, or metallic bath, or other means of heating at the juncture of the segments up to known temperatures, we should expect to find the deflections of the galvanometer increase steadily as the temperature of the bar or wire rises until the moment when such a heat is applied that annealing takes place in the *un*annealed segment of the wire. At this moment the thermo-electric current ceasing altogether, the needle will retrograde to zero, or to its original point, before heat was applied. This occurrence will signal the accomplishment of the molecular change, and the temperature at the moment may be read off from the pyrometric instrument employed and placed in the flame or furnace. Many precautions, some probable difficulties requiring preliminary experiments to disentangle, will readily occur to the physicien, and with him we must leave the subject now. It would be out of place here for us to enter more fully into a purely experimental subject. We have, we trust however, pointed out to the practical man some at least of the sources of difficulty and uncertainty that appertain to his operations of "shrinking on," and in doing so indicated the road by which, with the help of the man of experimental science, he may extricate himself from them.

At the commencement of this paper we put in words, another class of molecular changes, in virtue of which tyres, axles, cannon, and all things formed of metal are presumed, in course of wear and use, to become deteriorated, weakened, or destroyed, namely, crystallization produced by vibration. We shall reserve the consideration of this, however, to a separate article in a future number.

The subject is one of such great practical importance, it is one so little understood, it appears so ill-digested on the part of even some of our leading practical experimentalists on iron, and engineers, and is withal so frequently the subject-matter of ignorant or half informed remarks in our mechanical journals, and on the part of their correspondents, that we shall best devote to it a separate article.

Artificial Plumbago.

From the London Mining Journal, No. 1377.

For some time past, Dr. Crace-Calvert, F. R. S., has been engaged in experimenting upon the composition of a carboniferous substance existing in grey cast iron, or, to use a more popular definition, in producing plumbago from cast iron. The effect of his experiments has been to arrive at results which throw much light upon the chemical

composition of the substance, proving it to be composed of iron, carbon, nitrogen, and silicium. The substance occupies exactly the same volume as the cast iron from which it is obtained, and is sufficiently soft to be easily penetrated by a blade. The mode of experimenting pursued by Dr. Calvert, consisted in placing cubes, one centimetre in dimension, of Staffordshire cold-blast cast iron in corked bottles, with 80 times their volume of weak solutions (each 1 alkalimeter) of the following acids:—Sulphuric, nitric, hydrochloric, acetic, oxalic, tartaric, and gallic. Besides these, phosphoric, carbonic, oleic acids, tannin, and acid peat water, were also used. After three months of contact, he found that although the external appearance of the cubes was not changed in any of the vessels, still those in contact with the weak sulphuric, hydrochloric, and acetic acid solutions, especially the latter, had become so soft externally, that the blade could penetrate three or four millimetres into the cubes. He, therefore, removed the solutions from the vessels, and replaced them by an equal bulk of each weak acid solution, and continued to do so every month for two years, at the end of which time the cubes in contact with the acetic acid ceased to yield iron to the acid, although they were still of the original size; they had, therefore, become transformed into the carbonaceous substance, or artificial plumbago. The action of the weak acetic acid solution Dr. Calvert found to be complete, that of the hydrochloric and sulphuric solutions nearly so, and that of the nitric much less complete, whilst the other solutions either showed no similar action, or a very slight one.

The action of acetic acid on grey cast iron is most interesting; for instead of ceasing when saturated with oxide of iron, as is the case with other acids, its action is continuous, if the precaution be taken to close the mouth of the vessel with an ordinary cork. Thus he has had cubes of cast iron in contact with the same quantity of acetic acid for two years, and the chemical action still existed when the bottles were examined. This action of acetic acid appears, therefore, to be analogous to that which it has on lead. To examine the chemical composition of the cubes transformed by the action of acetic acid, they were reduced to a fine powder in an agate mortar, and well washed with boiled water slightly acidulated with acetic acid. The powder was then dried at 115° Cent. in a dry atmosphere of carbonic acid or hydrogen, according to the nature of the body to be determined in the mass. The cubes of grey cast iron, which originally weighed 15·324 grams., weighed after the two years treatment only 3·489 grammes, and their specific gravity was reduced from 7·858 to 2·751. From the figures, obtained upon careful analysis, it appears that the largest part of the nitrogen originally existing in the cast iron remains in the graphitoid substance, and only a small portion is transformed into ammonia. He has ascertained by direct experiments that it is silicium and not silica that enters into the composition of the carbonaceous mass. Like silicium, the quantity of carbon found in the carbonaceous compound does not represent the whole of the carbon pre-existing in the cast iron, as carburetted hydrogens are given

off during the slow action of the acetic acid in the iron. Dr. Calvert has found the carbonaceous compound (even after the acetic acid has ceased to act upon it) contains 79·960 per cent. of metallic iron—not oxide of iron. Though in the present state of his researches Dr. Calvert considers it would be premature to attempt to assign any definite composition to this substance, we may state that our inference is that it is a compound of sesquiferride of carbon with a nitride of silicium, and the following table given by him substantiates this view:

	Composition of the original views.	Composition of the carbonaceous substance.
Iron, . . .	95 413	79 960
Carbon, . .	2·900	11·020
Nitrogen, . .	0·790	2 590
Silicium, . .	0·478	6·070
Phosphorus, . .	0·132	0·059
Sulphur, . .	0 179	0·096
Lost, . . .	0·108 = 100·000	0·205 = 100·000

As Dr. Calvert's discovery has been referred to in a manner which would induce the opinion that his researches are nothing more than a repetition of those described in a paper "On Black Lead from Cast Iron," by Dr. J. Macculloch, communicated to the *Edinburgh Philosophical Journal* in 1822, we may take this opportunity of stating that the experiments of the two chemists were not similar, and that the results obtained are directly opposed to each other: Macculloch maintained that plumbago is a distinct metal, and that black lead is its oxide, whilst Calvert proves that plumbago (or rather that which Macculloch calls plumbago) is a compound of iron; being, in fact, a compound of about 91 per cent. of a subcarbide of iron, with about 8½ per cent. of a nitride of silicium, and traces of phosphorus and sulphur. Macculloch added little to that which was previously generally known on the subject; but Calvert has carried out his researches with such care and minuteness that we trust ere long to be enabled to give a final reliable opinion upon the subject. In the paper referred to, Dr. Macculloch describes certain experiments which he had made in consequence of his attention having been drawn to specimens of iron that had lain for years at the bottom of the sea, or had been subject to constant soakage in the porter-backs used at breweries. He notices the fact that certain iron guns, fished up in 1740 off Tobermory, from one of the sunken vessels of the Spanish Armada, had become so soft that they could be easily scraped, and that, wherever scraped, the surface of the metal grew too hot to be touched with the hand. A similar phenomenon was observed in some of the iron fittings that had been long exposed to the weak acid present in porter; the metal, moreover, had all the appearance of plumbago, and was not reduced in bulk. The Doctor tested his conclusions by experiments in the laboratory, and found that he could produce plumbago and black lead at pleasure, without any diminution in bulk of the pieces of iron ex-

perimented on; and that the converted metal always became hot if scraped, while any moisture remained, as had been remarked of the long-submerged cannon. In describing his experiments on the soaking of pieces of iron, he mentions that, to procure the black lead in perfection, the acid should be very weak, and the operation is then necessarily tedious. Acetous acid appears to be the best, and it is by this that it is produced in porter-backs, in the waste-pipes of breweries, and in calico-printing houses, where sour paste is used. If the experiment be perfect, the black lead becomes hot on exposure to air, smoking while there is any moisture to be evaporated, particularly when the surfaces are scraped off in succession, so as to give access to the air. Macculloch would thus appear to have proceeded little further than the point at which Calvert commences; for, if we assume the contrary to be the case, we could only come to the conclusion that to express the opinion, as the result of his researches, that the carbonaceous substance found in cast iron was a distinct metal, Macculloch must have been a very clumsy manipulator, and a chemist upon whom no reliance could be placed.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, March 20, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Chemical Society, the Zoological Society, and the Institute of Actuaries, London; la Société d'Encouragement pour l'Industrie Nationale, Paris, France; the Natural History Society of Montreal, Canada; the Bureau of Topographical Engineers, Hon. Willam D. Kelly, U. S. Congress, and Frederick Emmerick, Esq., Washington City, D. C.; Geo. R. Smith, Esq., Penna. Senate, and Rev. W. R. De Witt, State Librarian, Harrisburg, Penna.; the American Philosophical Society, the Pennsylvania Institution for the Instruction of the Blind, the Schuylkill Navigation Company, Prof. John F. Frazer, and William W. Hubbell, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of February was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (2) were proposed, and the candidates proposed at the last meeting (2) were duly elected.

The Actuary reported that the following Standing Committees have

organized by electing their Chairman, and appointing the time for holding their Stated Meetings, viz:

Committee.	*Chairman.*	*Time of Meeting.*
On Library,	James H. Cresson,	1st Tuesday evening.
" Exhibitions,	John E. Addicks,	1st Thursday "
" Models,	James Agnew,	2d Monday "
" Meetings,	Washington Jones,	Monday " previous to 3d Thursday.

Mr. Howson exhibited Mr. Gratz's patent Street Annunciator and Panoramic Advertiser, which consists of a box containing a number of rollers and bands; on the latter are printed the addresses of business houses and names of cross streets, if used on street cars, or of the stations, when placed on a railway car. It is operated by either the conductor or brakesman, who, on pulling a lever, rings a bell, and at the same time exposes to view the name of the street or station at which the car has arrived, together with the advertisement of any business house near the crossing or station.

The instrument is simple in its construction, and performs the duties intended with precision. It attracted much attention.

Mr. H. also exhibited a specimen of Mr. T. C. Andrews' Tobacco Pipe, in the bowl of which is placed a lining of porous clay, with a perforated bottom, to be withdrawn when it requires cleaning. The main object of the pipe, and one which is fully attained, is to prevent the nicotine from passing up the stem to the mouth of the smoker, the smoke being consequently milder, and free from the noxious ingredients contained in that drawn from ordinary pipes. Much of the nicotine is also absorbed by the porous clay lining, which may be cleaned by placing it on the coals of a fire, and burning out the matter absorbed.

The patent Axle Splice of Mr. J. E. Balderston was also exhibited. It consists of a block of wood or metal, with a journal at one end for receiving the wheel of a gun carriage or vehicle. If the axle breaks, this splice is secured, by clamps which are attached to the splice, to the broken part, so that an available journal is always presented, however near to the wheel the axle may break.

Mr. Howson also directed the attention of the members to specimens of metal, illustrating the manufacture of Cartridges in the different stages, as made by the very complete automatic machinery of Mr. C. Sharps. Also, a specimen of a new French Cartridge, on which Mr. Sharps has recently made an improvement.

Mr. Nystrom detailed some experiments made by him in repeating Fire Arms, where the barrel was filled with cartridges, to be exploded in succession by fuses running through the balls. He stated that he had been but partially successful.

One of the members remarked that a Mr. Chalmers, of West Middletown, Penna., had patented a gun in 1813, on the same principle, which operated successfully.

Mr. Thomas Shaw, of this city, exhibited a Revolver, illustrating an

improved mode of half-cocking self-cocking pistols. The effect is accomplished by the insertion of a single piece of steel, uniting and combining with the pawl of the hammer in such a manner as to effectually support the hammer away from the cap when not in use; and also to allow it to be perfectly free when firing, an object which heretofore has been rather difficult to accomplish. This arrangement was patented by Mr. Shaw Dec. 24, 1861.

Mr. A. L. Fleury presented some specimens of Iron and Steel, and remarked—

I have been engaged in various experiments on iron and steel, at Danville, Montour County, in order to test several of my improvements on a larger scale. The proprietors of the Pennsylvania Iron Works kindly gave me such facilities as their establishment afforded, and aided by my friend, Mr. Adams, I succeeded in obtaining some valuable results.

Abandoning the expensive batteries and costly induction apparatus, I have now adopted the broken current of a powerful magneto-electric machine, aided by such nitrogenous substances or gases as will aid in carrying off the impurities. After careful comparison with others, I have found these machines (now manufactured by Messrs. Collier & Co. in Binghampton, N. Y.) to be the best adapted to my purposes, because they are the least complicated and cheapest machines made in this country, and require no scientific knowledge and care; any workman can start the belt and stop it when required.

The samples of steel which I now submit for inspection, are made by my process from so-called cold short iron, such as is made from sileceous block ore. This steel is so hard that it will cut into chilled iron, and can be made on a large scale at from 6 to 8 cents per pound. The two samples of cast iron, the one treated in the mould with a current of electricity (broken, as before mentioned), the other cast at the same time and in the same sand, show plainly in their different grain that electricity has the property of changing the nature of the iron, rendering it stronger and more compact.

I have made arrangements with some parties near the City of Philadelphia, for the erection of model works, where can be followed up, practically as well as theoretically, all the various improvements made in the manufacture of iron and steel, and shall be happy to give ocular demonstration of the progress made in this department.

I regret that on account of the weight (about 900 lbs.), and the steam power required for its motion, I am prevented from exhibiting to the members the magneto-electric machine, which I have brought with me from Binghampton. This machine, furnishing a quantitive current equal to one produced by 120 Smee's batteries 4×6, is intended for electro-plating, and will be practically tested by Mr. J. O. Mead, of this city.

Another machine, still larger, and weighing nearly two tons, with 32 magnets, (similar to the one presented for your inspection,) will be finished and sent to me by Messrs. Collier & Co. in about two weeks, when the electric light will be tested in various places on Chestnut

street. Details of all the arrangements will be presented at the next meeting.

Mr. B. H. Bartol exhibited to the meeting several diagrams of the iron-clad steamer *Monitor*, a section of the vessel building at Mystic, Conn., and a model of the one now being built by Merrick & Sons, of this city.

He stated that, while the credit of designing and constructing the *Monitor* belonged to Capt. Ericsson, it was but just to say that the plan of a revolving turret was not his. In fact, Capt. E. had himself, in a recent letter to the editor of the New York *Times*, specially disclaimed being the originator of it, but claiming the peculiar details of the vessel as his. The recent trial of the *Monitor* with the *Merrimac*, while it proved the former's ability to resist the shot of the latter, and in so far was a success, yet her ability to attack and capture has yet to be proved.

A perfectly successful iron-plated war steamer must not be simply a vessel for harbor defence; she must with certainty be able to go along our coast unaided, and in moderately rough weather; and her accommodations must not be a dungeon, requiring artificial light and ventilation. Comfort in time of peace, security in war, and a fair speed, are the essential elements of a war vessel.

The three vessels now building by the Navy Department, were authorized by a law of Congress passed last August, appropriating $1,500,000 for iron-clad vessels. Plans and proposals were advertised for, and a board consisting of Commodores Smith and Paulding, and Capts. Davis and Dahlgren, appointed by the Secretary of the Navy to examine plans and report. This board recommended the three vessels that have been mentioned, of which the *Monitor* is the first. The Mystic vessel will probably be out in May. She is a wooden vessel, plated with two thicknesses of bars, running longitudinally, secured to the wood by through bolts with nuts on the inside. These plates lap on each other in such a way that the head of the bolt is protected on the outside from shot. Her guns are placed on her deck, and above it is a covering of moderately thick sheet iron, which cannot be shot proof, but will no doubt resist musket or rifle balls.

The vessel building in this city by Merrick & Sons, is of timber, plated with iron. She is 240 feet long on deck, 58½ feet beam, and 25 feet hold; 3500 tons; greatest draft of water, 15 feet. She has a berth, gun, and spar deck. She is plated with 4½ inch iron, her whole length for 4 feet below and 3 feet above load line. From that point to spar deck, she is plated 170 feet amidships, and has iron-plated bulkheads across ship at the termination of the side plating. Her spar deck consists of 3 ins. of wood and 1 in. of iron; thus, a clear space on the gun deck, 170 feet long by 54 feet wide, is impervious to shot, unless one enters at the porthole. The battery of this vessel will consist of sixteen 9-inch guns, eight on a side, and a couple of light rifle guns at bow and stern on her spar deck, for chasing and bringing to distant vessels, while her large guns are for engaging war

vessels or land batteries. It is believed that her powers of resistance will enable her to go alongside of any vessel or fort with impunity, while from her large size, she can carry a sufficient force to capture the vessel she may disable. Her speed is to be $9\frac{1}{2}$ knots per hour; at which, with her iron prow in front, she would sink any vessel with which she might come in contact. She is to have three masts, and to be barque rigged; her spars so arranged that, when in action, they all come down to the spar deck. Her machinery consists of two horizontal condensing engines, with cylinders 50 ins. diam. × 30 ins. stroke, to make 85 revolutions turning a 13 ft. propeller. Four horizontal tubular boilers capable of developing 1600 horse power. Coal bunks for ten days steaming. From which it will be seen that this vessel is a cruising ship that may be sent under steam or sail to any part of the world, requiring neither artificial light or ventilation; while those vessels which are purely floating batteries, will rust out at anchor in times of peace.

The construction of iron-clad vessels will make an entire change in naval warfare; and, while it is positive that our reliance for safety is to be in vessels of this class, yet at the same time we should proceed with caution, and not rush headlong into the construction of a large number of vessels, before any one plan has been fully tested. At the present crisis, we should build about a dozen vessels of from 10 to 15 feet draft of water, each of which should have fair speed, and carry in front below the water line an iron prow, for penetrating any vessel with which they may come in contact.

[NOTE.—Revolving turrets or towers, similar to that on the *Monitor*, were patented by Capt. C. P. Coles, of the English Navy, Mar. 30th, 1859, and experimentally applied to the steamer *Trusty*, in August, 1860.]

Mr. B. also exhibited to the meeting a model of a plan for closing ports (when the gun was run in), designed by Chief Engineer W. W. Wood, of the U. S. Navy, and remarked that it was very desirable to have some convenient and secure way of rendering ports ball-proof; but it was exceedingly difficult to devise a plan without having the doors exceedingly heavy, and consequently unwieldy.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

FEBRUARY.—The temperature of February, 1862, was $7\frac{1}{2}$ degrees below that of the same month of 1861, and about $1\frac{1}{2}°$ below the average temperature of the month for eleven years.

The warmest day of the month was the 13th, of which the mean temperature was 42·2°. The maximum for the month (52°) was reached on the same day.

The coldest day was the 10th, with a mean temperature of 22·8°. The minimum (16°) was reached on the same day.

The range of temperature for the month was 36°.

The temperature was below the freezing point on 23 days of the month, though it rose above that point in the course of every day except six, namely, the 3d, 4th, 10th, 21st, 25th, and 28th.

The greatest change of temperature in the course of one day was 22°, on the 12th day of the month; the least was 5°, on the 1st. The average daily oscillation of temperature for the month (10·89°) was 2½° below the average oscillation for the month of February, and was less than occurred in that month since the year 1855, when it was 10·2°.

The greatest mean daily range of temperature was 13·2°, and occurred between the 14th and 15th days of the month; the least was 1°, and occurred between the last day of January and the first of February. The average daily range for the month (5·55°) still continues below the average range. It was nearly 3½° below that for February, 1861, and nearly 2° below the average for eleven years. It was the smallest mean daily range observed in any February during the eleven years of observation. The nearest approach to it was 5·8°, in February, 1855.

The pressure of the atmosphere was greatest on the 16th of the month, when the barometric height corrected for temperature was 30·322 inches. The greatest mean pressure for a day was 30·253 inches, on the 16th. The pressure was least (29·216 ins.) on the afternoon of the 24th. The least mean pressure for a day was 29·454 inches on the 24th. The average pressure for the month (29·917 ins.) was a little less than that for February, 1861, but a little more than the mean pressure for eleven years. The exact difference will be seen in the following table of comparisons.

The greatest mean daily range of atmospheric pressure was 0·717 of an inch, and occurred between the 24th and 25th days of the month; the least was 0·028 of an inch, between the 22d and 23d. The average mean daily range for the month (0·225 in.) was very near the general average for the month of February for eleven years.

The force of vapor was less than usual, at 2 and 9 P. M.; though it was very near the average at 7 A. M. It was greatest (0·267 in.) on the morning of the 24th, and least (0·060 in.) on the morning of the next day, the 25th. The average for the month was sixteen-hundredths of an inch below the general average.

The dew-point following the force of vapor was highest (42°) on the morning of the 24th, and lowest (7·3°) on the 25th. It was about 1° below the general average for February.

The relative humidity was greatest (100 per cent.,) during a fog on the morning of the 24th, and least (44 per cent.) on the afternoon of the 28th. The average humidity for the month was nearly 10 per cent. greater than for February, 1861, and a little over 1 per cent. greater than the average for eleven years.

Rain or snow fell on fifteen days of the month, to the aggregate

depth of 4·277 inches. The number of rainy days was greater than ever before observed in the month of February, the nearest approach to it being 14 days in February, 1859. The amount of rain and melted snow that fell, was an inch and a half more than the average amount for eleven years, and was more than fell during the month in any year, since 1853, when 4·44 inches fell.

Snow fell on eight days of the month, to the aggregate depth of about two feet, but as it was generally soon followed by rain, it remained but a short time on the ground.

There was but one day of the month, the 5th, entirely clear or free from clouds at the hours of observation, and the sky was completely covered with clouds at those hours on nine days. The average amount of the sky covered with clouds during the month of February, 1862, was about 70 per cent.; during February, 1861, it was 58 per cent., and the average amount for eleven years is but 56 per cent. of the hemisphere.

A Comparison of some of the Meteorological Phenomena of FEBRUARY, 1862, *with those of* FEBRUARY, 1861, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Feb. 1862.	Feb. 1861.	Feb. 11 years.
Thermometer.—Highest, . .	52°	68·5°	70·0°
" Lowest, . .	16	— 1·0	— 1·0
" Mean daily oscillation,	10·89	17·27	13·40
" Mean daily range,	5·55	8·90	7·29
" Means at 7 A. M.,	28·36	33·86	29·14
" " 2 P. M.,	36·00	45·55	38·44
" " 9 P. M.,	31·64	39·14	33·38
" " for the month,	32·00	39·52	33·65
Barometer.—Highest, . .	30·322 in.	30·485 in.	30·638 in.
" Lowest, . . .	29·216	29·308	29·065
" Mean daily range, .	·225	·264	·221
" Means at 7 A. M., .	29·939	29·954	29·921
" " 2 P. M., .	29·891	29·912	29·873
" " 9 P. M., .	29·922	29·951	29·903
" " for the month,	29·917	29·939	29·899
Force of Vapor.—Means at 7 A. M.,	·130 in.	·158 in.	·139 in.
" " " 2 P. M.,	·143	·169	·164
" " " 9 P. M.,	·142	·186	·160
" " " for the month,	·138	·171	·154
Relative Humidity.—Means at 7 A.M.,	80·4 per ct.	75·0 per ct.	79·6 per ct.
" " " 2 P.M.,	66·6	52·5	64·7
" " " 9 P.M.,	77·9	69·7	76·8
" " " for the month,	75.0	65·7	73·7
Rain and melted snow, amount	4·277 in.	2·124 in.	2·815 in.
No. of days on which rain or snow fell,	15·	9·	10·2
Prevailing winds—Times in 1000-ths,	N.45°0′W.·208	S. 77° 6′W ·354	N70°26′W ·292

WINTER.—The Winter of 1861–62, was less than half a degree warmer than the average Winter temperature for the last eleven years.

The warmest day was the 9th of December, 1861, of which the mean temperature was 54·2°. The coldest day was the 5th of January, mean temperature 18·8°. The highest degree (64) was reached on the 10th of December; and the lowest (10) on the 5th of January.

The pressure of the atmosphere was nearly two-hundredths of an inch greater than the average winter pressure for the last eleven years.

The force of vapor was greater at 7 A. M., and less at 2 P. M., than usual, but the average for the winter, was almost precisely the same as for the preceding winter, and but two-thousandths of an inch less than the average for eleven years. The relative humidity was two per cent. greater than that of the preceding winter, but was very close to the average for the whole period of observation.

Rain fell on thirty-five days to the aggregate depth of 10·793 ins., which is more than an inch above the average.

The prevailing winds during the winter, came from a point about eighteen degrees north of their direction for the winter 1860–61 and about fifteen degrees north of their average direction for eleven years.

A Comparison of the WINTER *of* 1861–62, *with that of* 1860–61, *and of the same Season for* ELEVEN *years, at Philadelphia, Pa.*

	Winter, 1861–62.	Winter, 1860–61.	Winter, 11 Years.
Thermometer.—Highest,	64·0°	68·5°	71·0°
" Lowest,	10·0	— 1·0	— 5 5
" Mean daily oscillation,	11 89	13·69	12·47
" " daily range,	5·42	6·63	6·76
" Means at 7 A. M.,	30 08	30·28	29·45
" " 2 P. M.,	37·58	38·51	37·56
" " 9 P. M.,	33·16	33·95	32·95
" " for the Winter,	33·60	34·25	33·32
Barometer.—Highest,	30·462 in.	30·526 in.	30 462 in.
" Lowest,	29·216	29·285	29·216
" Mean daily range,	·233	·230	·215
" Means at 7 A. M.,	29·973	29·961	29·953
" " 2 P. M.,	29·926	29·925	29·911
" " 9 P. M.,	29 955	29·959	29·937
" " for the Winter,	29·951	29·949	29·934
Force of Vapor.—Means at 7 A. M.,	·140 in	·139 in.	·138 in.
" " " 2 P. M.,	·154	·151	·162
" " " 9 P. M.,	·152	·155	·153
" " " for the Winter,	·149	·148	·151
Relative Humidity.—Means at 7 A. M.,	80 0 per ct.	78·1 per ct.	79 1 per ct.
" " " 2 P. M.,	66·4	63·4	66·7
" " " 9 P. M.,	77·3	74·4	76·5
" " " for the Winter,	74·6	72·0	74·1
Rain and melted snow, amount	10 793 in.	10·045 in.	9·750 in.
No. of days on which rain or snow fell,	35	30·	30·7
Prevailing winds—Times in 1000-ths,	N47°35′ W·274	N.65°37′W·354	N.62° 8′W·305

JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

MAY, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

No. 1.—RESERVOIR CONSTRUCTION.

THE principle of collecting water for public or personal use, is directly connected with the introduction of water works; and preliminary to examination of the several theories or systems of construction and use which have been followed, a brief historical summary of ancient and modern practice is important, which is taken from Cresy's Encyclopædia and other works for the former, and principally from local reports for the latter.

Egypt.—In two of the prominent cities, Carthage and Alexandria, the former containing upwards of 700,000 inhabitants and the latter over 300,000, the first received its supply of water through a large aqueduct, which emptied itself into a great number of reservoirs or cisterns in different parts of the city, about 100 feet long by 30 feet wide, through earthen pipes laid for the purpose, said to be still visible; while the second was supplied from the river Nile, covered stone conduits lined with cement being carried to each private dwelling, discharging into small cisterns built for the purpose, of the same material and lining, also covered. In the wars between Rome and Alexandria, when the Roman army had obtained possession of a portion of the city, they were much surprised and annoyed by the Alexandrian general, who cut off their supply of fresh water, turning into their conduits salt water in its stead; but by their united exertions in a single night, they dug wells sufficient to supply their wants. The fact,

taken in connexion with the enormous cost of this system of distribution, goes to show very clearly their care to provide the wholesome water of a river, in preference to the unwholesome water of wells, where used by a large population. While, in the case of Carthage, these numerous reservoirs would seem to have been used for direct private supply, without introduction to each house, as is now the case in some European cities.

Recent visits to the remains of Utica, by H. B. M. ship *Harpy*, describe the main subterranean reservoir of about 320 feet diameter, with six cisterns 86 feet from it, 135 feet long, 19 feet 7 inches wide, not less than 17 feet deep, built with arched roofs, connected with each other, and in good preservation.

Greece.—On the island of Samos, a canal was cut through a mountain to obtain the supply of water from a copious and celebrated spring; and at a point near the aqueduct, several caverns were cut to receive its supply, whence the water was probably drawn by hand for use.

On the island of Tenedos there still remains an ancient stone building, in which the water used by the inhabitants was collected, after it was brought from distant springs in earthen pipes.

Among other remains of the city of Cnidus are several slabs of marble, channeled out for water conduits.

On the island of Cos, an aqueduct three miles in length is built, which supplies the inhabitants, the cover being removed to enable them to get at its contents.

In the city cf Syracuse, one of the reservoirs is described as being cut out of the solid rock, as was the aqueduct which supplied it, being 57 feet long, 23 feet wide, and 10 feet deep.

In other Grecian cities conduits of stone masonry are found leading to subterranean reservoirs, arranged in a similar system of distribution.

Italy.—In the arrangements for distribution made by the engineers of Rome, the water brought to the city by the several aqueducts was received at the walls of the city in reservoirs specially adapted to each supply. The levels of the several sources at these reservoirs differed materially, that of the Anio Novus being 158·8 feet above the level of the Tiber; while of the six other aqueducts, three were above a level of 125 feet, and the other three standing at 82·5, 34·2, and 27·4 feet above this river, which at the city was 91·5 feet above the Mediterranean.

Each reservoir, or *castellum*, had "a triple cistern attached to it to receive the water. Three conduits, of equal dimensions, were connected in such a manner that when the water was more than necessary for the supply of the outer, it was discharged into that of the middle, which served all the pipes of the public fountains; one of the mains supplied the baths, the other the private houses. The object of this contrivance was to provide first for the public wants, then the baths, and afterwards private individuals.

"At the end of each of these three conduits was a receptacle

whence the general distribution was made; at the sides were two others, to take off any superabundant quantity. By such an arrangement the various supplies were regulated with the greatest nicety. The total width of the *castellum* (of the Aqua Julia) is 115 feet. No expense was spared in the construction of these stupendous edifices, which, attached to the numerous aqueducts of Rome, must have resembled palaces. Built of squared stone, and lined with brick coated with a fine cement, every precaution was taken to prevent leakage or infiltration. The several conduits and pipes were provided with valves and cocks, for shutting off or turning on a supply to any direction."—*Cresy's Encyclopædia*, p. 172.

Ample provision was also made for cleansing the several chambers by flushing ports, built in the centre, and secured by a plug or a cut stone.

Every house in Rome was supplied with water, a portion of the expenses being met by private tax on each house. In many cases fountains were placed in the courts, and in others cisterns were used, either open or covered. These were supplied from the *castellum*, principally by earthen pipes, although lead pipes were much in use in Italy. Wooden pipes were sometimes used for economy; pipes of terra cotta were also used, and iron pipes were not unknown. In some of the baths copper pipes were used, but seem to have been limited in number.

The Romans seem to have preferred the earthen pipes for distribution, as they did earthen vessels for drinking, on account of their superior coolness and purity. The tubes were made not less than two inches thick, the end of one fitting into that of the other. The joints were coated with a mixture of quicklime and oil, the pipes resting on stone blocks, to keep them in line, and in some cases they were entirely coated with cement.

In the city of Venice, all the springs met with in constructing the foundations of the houses were led into wells built to receive them. In the absence of a spring, the wells were supplied by rain water from the roof, and these supplies failing, as they sometimes do, recourse is had to the main shore for supplies brought in boats. These subterranean reservoirs are very carefully built, lined with a peculiar clay of the locality, and preserve the water in coolness and purity.

In other cities of Italy the population is supplied by public reservoirs, placed at different points throughout the city, at a level below the ground.

Turkey.—In the city of Constantinople, one of the covered reservoirs, or *cisternæ*, connected with the distribution system, still remains. It is constructed of brick covered with cement. It has a vaulted roof supported by marble columns, the cistern being 336 feet long, about 200 feet broad, and containing when filled to about 40 feet depth 25,000,000 gallons of water.

Remains of these *cisternæ* are found in Rome, independent of the *castellæ*, which received the aqueduct supply. They are also to be found in Spain.

Judea.—The city of Jerusalem is still supplied in part from the pools of Solomon, which were cisterns or reservoirs of masonry, receiving an aqueduct discharge, and works of this kind characterize that country.

The countries of Assyria and Persia, Babylon and other great cities, contained extensive provisions for water supply.

Peru.—In this country reservoirs were constructed by the Incas on the Andes, from which aqueducts were built hundreds of miles in length, exceeding in character those of Rome. One, in the valley of Condesuyu is four hundred miles long, and is still in partial use.

Mexico is also famous for the aqueduct of Chapultepec, and the line over Lake Tezcuso.

It would appear from these statements, that with the ancients the system of distribution to each private house was not universally in use, the inhabitants being obliged to go to the *cisternæ* for their more immediate supply. And, as in those cases on record, of house distribution, the open fountains, open *limariæ*, or covered *piscinæ*, were at or below the level of the ground, and fully connected by waste pipes with the system of sewerage, it is evident that the system of distribution *under pressure* was not in general use, so far as an available head within the house was concerned.

Modern Europe.—In a large number of European cities, as has been also the custom in Canadian cities, and as was the practice for many years in New York, the population is supplied from the public fountains or other sources by water carriers. The supply of the *Canal de l'Ourcq* in Paris was distributed in this way.

In other cities, as in London and Hamburg, the supply is carried to the consumers by distributing pipes, under the pressure of standpipes connected with pumping engines, reservoirs being used rather as reserves for fire purposes than for house service.

London, previous to the year 1582, derived its supply by individual resort to the Thames, to wells, and to suburban streams. About that time a tide-wheel was erected at London Bridge, which forced the water of the Thames into a cistern on a wooden building 120 feet high, from which leaden pipes carried its supply to several districts of the city, pipes of wood and stone being in occasional use at a later date. With this distribution service, under additional pumping power, which was mainly of wood up to 1810 and 1815, as also in other cities of England, the greatest head in the houses was limited to 6 feet above ground.

The character of the supply furnished the citizens of London by the nine water companies in operation previous to 1852, has this remarkable peculiarity, that it was carried on under what is called the *intermittent system*, or in other words, that each company subdivided its distribution district into convenient sections, but one of which was supplied at a time, and in no case more than once a day, sometimes not more than three times a week; and that the supply of water under the standpipe head at the engine house, was kept on each section for a daily interval varying from three-quarters of an hour to three hours,

but very rarely as long as three hours. Notwithstanding the use of cast iron distribution pipes, the elevation of this intermittent supply to the upper stories of dwellings was confined to the more expensive houses, and as a general rule, all the supplies were received in cisterns or other receptacles very near or quite below the street grade. In most cases the mains were supplied direct from the engines through the engine house standpipes, a process for which these standpipes were specially adapted.

To receive and retain for use this alternate supply, all the better class of houses were provided with cisterns, or water butts of sufficient capacity for this purpose. No such provision, however, seems to have been made for the poorer classes, who were obliged to draw their supply from short standpipes placed in the several courts, one pipe of this kind serving for from 50 to 100 houses, the water being kept in the pails, jars, buckets, &c., in which it was caught.

From the Parliamentary Reports on this subject of 1850, it appears that of 288,037 houses in the city district of supply, 17,456 houses, or about 6 per cent., were unsupplied by any direct means; in special districts the ratio sometimes being as high as 18 per cent.

In the several Reports of 1850, '51, and '52, on the disadvantages of the present London supply, the objections to this peculiarity, which also prevails in many other cities of Great Britain, are clearly and strongly urged.

The New River Company has six subsiding reservoirs within the city limits, and uses six engine stations. Two are lined with brickwork, the others being excavated in clay bottom, with side slopes of 2·5 to 1, faced with broken stone for protection from wash. Two, being 86 feet above Trinity datum, supply by gravitation. The highest service is 430 feet. Their joint area is 50 acres; level, 82, 86, 112, 154, and 400 feet; contents, about 8·5 days supply, as an average, the highest holding 1 day's supply; joint contents, 120,268,176 gallons. Daily distribution in 1849, 14,149,315 gallons.

The East London Company has five subsiding reservoirs, at datum level, 30½ acres area jointly. Contents, 32,500,000 gallons. Lined in part with Kentish ragstone, brickwork, and gravel. The sixth, lined with brickwork, on Stamford Hill, is 86 feet above, and contains 2,500,000 gallons. Daily distribution in 1850, 8,829,462 gallons; highest service, 120 feet.

The Southwark and Vauxhall Company has no reservoirs, except for subsidence and filtration from the Thames. Highest service, 185 feet.

The West Middlesex Company has two subsiding reservoirs from the Thames of 16 acres area; a reservoir on Camden Hill, less than 1 acre in area, lined with brickwork, at 111·5 feet level, containing 3,456,000 gallons; and another on Barrow Hill, lined with brick, 1·5 acres area, contents, 4,572,000 gallons, level, 167·5 feet. Daily distribution in 1849, 3,334,054 gallons; highest service, 207·5 feet.

The Lambeth Company has a reservoir on Brixton Hill, lined with brickwork with paved bottom, level, 105 feet, area, 3 acres, contents,

12,150,000 gallons, depth, 20 feet; and another on Streatham Hill, with brick walls and clay bottom, level, 185 feet, area, 1·25 acres, contents, 3,750,000 gallons. Daily distribution in 1849, 3,077,260 gallons; highest service, 350 feet.

The Chelsea Company pumps into a subsiding reservoir at low grade, 3·5 acres area, 15 feet deep. It has a reservoir at Green Park with brick walls and paved bottom, 10 feet deep, area, 1·5 acres, contents, 3,000,000 gallons; and one at Hyde Park with brick walls on concrete, area, 0·75 acre, 7 feet deep, contents, 1,021,000 gallons. Daily distribution in 1849, 3,940,730 galls.; highest service, 157 feet.

The Grand Junction Company has one reservoir at Camden Hill, with slopes lined with concrete and brick paved bottom: area, 1·75 acres; contents, 6,000,000 gallons; level, 123 feet. Daily distribution in 1849, 3,523,013 gallons; highest service, 150 feet.

The Kent Company has three reservoirs lined with concrete or Kentish ragstone: one at Greenwich Park, level, 140 feet; one at Deptford, level, 100 feet; and one at Woolwich Common, level, 200 feet. Joint capacity, 3,865,344 galls. Daily distribution in 1849, 1,079,311 gallons; highest service, 220 feet.

The Hampstead Company has a joint reservoir surface of 35 acres. Daily distribution, 427,468 gallons; highest service, 215 feet.

The metropolitan district supplied by these nine companies is about 10·5 miles long by 8 miles wide; total average daily distribution in 1849, 44,383,332 gallons; population supplied, 2,156,417; joint elevated reservoir contents, 206,000,000 gallons. From these statements may be inferred the relation borne by the London reservoirs to the distribution service, as to elevation and capacity, and the general plan of arrangement adopted.

The new supply of the Chelsea Company at Thames Ditton, embraces a supply and summit reservoir on Putney Heath, 6 miles from the engines, and 165 feet level. It combines a double covered and a small open reservoir, the former for domestic use, the latter for park and street purposes. The former is in two divisions, 20 feet deep, each 310 by 160 feet surface; contents of both, 10,150,000 gallons. The inside slopes are one to one, faced with concrete, with which the bottom is covered 1 foot thick. The roofing is of 8-inch brick arches on piers, with concrete filling in the branches, and covered with puddling. This supply inaugurates the *constant system*, or system of constant pressure for London.

Liverpool and *Glasgow* are examples of this system as in use in the United States. The Rivington Pike Reservoir is capable of supplying the former with 13,000,000 gallons daily; and for the latter, the Ryat Linn, added to the Waulkmill Glen Reservoir, the one at 298·3 feet, and the other at 283 feet level, 50 feet deep, hold 50,000,000 cubic feet of water, at a point 5 miles from the city. A filtering apartment is in use here, passing over 3,000,000 gallons per day. In cases of this kind, where flat bank slopes 3 to 1 are used, they are generally protected by rip rap walls, or a mixture of furnace cinders and small stones with clay.

United States.—Notices of a few reservoirs in this country will serve to illustrate the subjects of discussion.

The Beacon Hill Reservoir, Boston, is the most elaborate structure of its class. It is a rectangle, built above the street grades, the walls being from 41 to 58 feet high. The outside walls are built in solid cut granite masonry, with a heavy ornamental coping, the inner walls being of the same material, 5 feet thick at the base, on a concrete bed, and 3 feet at the top; the floor is paved with concrete 3 feet deep, and covered with two courses of brickwork. The level is 121·53 feet, depth of water way 13·5 feet, contents 2,678,961 gallons. The average depth in 1861, in consequence of extraordinary city consumption, was 9 feet.

The Murray Hill Reservoir, New York, is built in two distinct divisions, with retaining walls of heavy stone masonry, arched cells being constructed around the entire structure, behind the face walls; its coping grade is about 49 feet above the street. Its division wall is of concrete faced with rubble masonry, 18 feet wide at base, 7 feet at flow line, built on a concrete bed, and carried up to coping level. Its inner slopes, 1 to 1, are laid in stone masonry 15 inches thick, to 4 feet above bottom, whence they are covered with 12 ins. of concrete, also continued over the whole floor. Its level is 112 feet; contents, 38 feet deep, 21,000,000 gallons; its inner size is 386 feet square. Its flow line is 4 feet below inner coping. Its ordinary depth is about one-third of its full depth.

Prospect Hill Reservoir, Brooklyn, is built in earth-work. The inner slopes, 1·5 to 1, are puddled 2 feet thick, covered with 3 inches of concrete, and 8 inches of brickwork to the top angle, which has a coping 3 feet wide, on masonry bed. The floor is puddled 2 feet deep, covered with 4 inch brickwork grouted. Its contents are 20,000,000 gallons, depth 20 feet, level 197 feet.

The Cleveland Reservoir is on embankment, with a base 21 feet above grade. Earth retaining banks are constructed 25 feet high, inner slopes 1·75 to 1, outer 1·5 to 1. The slopes and floor are covered with 2 feet of puddling, with a facing of brick masonry. Its depth is 20 feet, level 150 feet, contents 6,000,000 gallons.

The new Reservoir, Fairmount, completed in 1852, is of earth work, with inside slopes of 1·5 to 1, lined with puddled brick-clay, 12 to 15 inches deep, covered with a layer of concrete, on which 4-inch brick masonry is laid; at the foot of the slope the brickwork abutment is 8 inches thick; the bottom is puddled, covered with brick laid flat and grouted. Its water surface is over 4 acres, contents 20,321,392 galls., depth 16 feet, level 98·14 feet. This completes the group of five divisions for this district, which are used for subsidence and supply, and aggregate 47,218,028 gallons capacity.

The Belleville Reservoir, Jersey City, N. J., is of earth work, with puddled slopes and floor, inside slopes 1·5 to 1, covered with concrete mortar and 4-inch brickwork, which is backed with rubble masonry for 5 feet below top angle, 18 inches thick. Level 158·83, contents

14,000,000 gallons, inner size 323 by 396 feet; level of force tube discharge 160·79.

The Louisville Reservoir is built in two connected divisions, in earth work, the banks being carefully worked down; inside slopes 1·5 to 1, covered with 4-inch brick masonry, which is 8 inches thick to a point 6 feet above bottom, the floor being puddled and covered with two dry flat courses of bricks. Its level is 150 feet, depth of water 20 feet, division banks 12 feet high, and 12 feet wide at top; contents 7,000,000 gallons; height of standpipe 180 feet.

The Detroit Reservoir is built in two distinct divisions, with embankments of soluble clay, carefully made, with interior puddle walls. The inner slopes are 1·5 to 1, faced with 4-inch brickwork, commenced with the intended use of 3-inch concrete backing, which does not appear to have been completed. The upper wall was laid in a temporary manner. Its level is 77·5 feet, contents 7,592,704 gallons, depth 25·5 feet, flow line 3 feet below top angle; division wall 10 feet wide at top.

The Manhattan Reservoir, New York, is built in two distinct divisions of different areas and depths, which can be connected by a pipe 15 feet below flow line. It has earth embankments, with outer retaining walls of heavy masonry, laid dry and pointed with cement. Its interior slopes are 1·5 to 1, paved with heavy dry wall from the rock blasted from its bottom. The banks have interior puddled walls. Its depths are 20 and 25 ft., water surface 31 acres, contents 150,000,000 gallons, level 115 feet. The floor is partly on rock, and is not puddled.

The new Croton Reservoir, under the specifications of 1857, is built of earth work, in two connected divisions, the top of division wall being 3 feet below flow line. The banks, which are 15 feet wide at top, and 4 feet above flow line, have interior puddle walls; the inside slopes are 1·5 to 1, covered with an 18-inch dry wall laid on 8 inches of small stones. The head of the division bank is protected by 18 inches of rubble masonry on 8 inches of concrete, carried with 10 feet face down the slopes. The puddle walls are commenced on concrete beds, or the rock-face, the floors not being puddled. Its depth is 38 feet, water area 96 acres, contents 1,029,880,145 galls. (N. Y.), level 115 feet. In 1859, the plan of slope lining was changed for a wall of solid rubble masonry.

The Hartford Reservoir is small and irregular in form, built in earth work, of compact material. Its inner slopes vary from 1·5 and 2 to 1, on different sides, and are faced with two courses of dry stone, each 9 inches thick. Puddle walls are built in the banks. Its depth is 30 feet, greatest inner length 395 feet, and width 187 feet; contents 7,830,000 gallons, level 120·94 feet.

Ridgewood Reservoir, Brooklyn, is of earth work, in two distinct divisions. The puddling is made two feet thick on all slopes excavated, and in walls, in all embankments, being carefully connected with the floor puddling, which is 18 to 24 inches thick. The inside slopes, 1·5 to 1, were covered with a dry wall of 16 inches, and had a 6-inch backing of small stones for a depth of 8 feet below flow line. This being injured by the action of surface waves in 1859, was carefully relaid

where necessary, and pointed for a depth of several inches in cement. Its depth is 20 feet, water surface 25·61 acres, contents 153,956,402 gallons, level 170 feet.

The Brookline Reservoir, Boston, which is chiefly a natural basin, has its inner slope lined with dry stone 18 inches thick, for a belt of 14 feet in width. This width was increased on account of the action of surface waves and ice. Its depth varies from 14 feet to 24 feet; contents 89,909,730 gallons, water surface 6 feet below top bank 22·31 acres, level of this surface 120·6 feet.

All the reservoirs of this country are arranged upon the *constant service* system, although instances occur of the use of standpipes, which are made to act as reservoirs under this principle, as in the Twenty-fourth ward works at Philadelphia.

(To be Continued.)

The Economic Angles in Parallel Open-work Girders.

From the Lond. Civ. Eng. and Arch. Journal, March, 1862.

Under the term open-work girders, we include all properly braced girders, whether the bracing be of the triangular character made use of in warren and lattice bridges, or of the diagonal description common in structures of older date, and in which the frame is subdivided into quadrilateral openings, which have their diagonals supplied with ties or struts.

We purpose first to point out what influence (if any) the upper and lower members of the structure, sometimes called the booms, have upon the question, when the whole material required for these, together with that for the braces, is to be rendered a minimum.

In estimating the quantity of material necessary for the different parts, we require for our present object their proportional values only. And where no great precision is demanded, we may treat of the strength of struts like ties, as independent of their lengths within moderate limits. In this preparatory discussion, we shall not draw any distinction between the amounts of material required for struts and ties subjected to equal stresses, but represent the quantity or cost or weight of any strut or tie as proportional to its length multiplied by the stress acting through it: the most convenient units of length, and of stress or weight, being chosen.

Fig. 1.

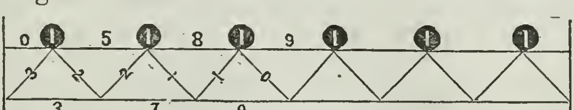
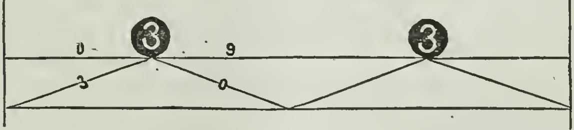


Fig. 2.



In Figs. 1 to 12, let the depth D be the same in each, and let it be taken as the unit for length; let also the span S in each = 12 times

the depth. Further, let the loading be spread uniformly over the top at the rate of $\frac{1}{2} w$ per unit of length; or $6\,w = \text{w}$, over the whole span of twelve units in length; w represents the unit of weight or stress = loading spread over a length of the span measuring 2 D. Let N be taken generally to represent the number of bays or parts into which the span is divided by the points at which the roadway or top-boom is supported by the bracings; when there is but one series of braces, N will be the number of triangles making up the span. Let θ represent the angle which a brace makes with the vertical, and a the angle which it makes with the horizontal direction. In Figs. 1 and 2, in which N is respectively equal to 6 and 2, let us first adopt the very usual supposition that each of the apices of the triangles receives the same share of the loading $= 6\,w \div \text{N}$. By the principles on which the stresses on such structures are calculated, we can readily affix to each brace, as is done in these figures, a number to denote in units the vertical component of the stress acting upon it, when all the loading is on the structure (the stresses on the booms being then the greatest). Knowing the vertical component of the stress on a brace, we obtain the horizontal stress which it induces in the booms, by multiplying the former by the tangent of θ. And since the depth of the structure is taken equal to unity, the tangent of θ is simply the horizontal stretch of the brace. Proceeding on these principles, we obtain the stresses on the booms marked against the various parts in the figures;* and to obtain the proportional quantities of the materials for the booms, we have merely to multiply these stresses by the respective lengths, thus:

$$\begin{array}{l} \text{Fig. 1.} \\ \text{N} = 6 \end{array} \left\{ \begin{array}{l} \text{Top} \quad\;\; = (5\times2+8\times2+9\times1)2 = 70 \\ \text{Bottom} = (3\times2+7\times2+9\times2)2 = 76 \end{array} \right\} = 146.$$

$$\begin{array}{l} \text{Fig. 2.} \\ \text{N} = 2 \end{array} \left\{ \begin{array}{ll} \text{Top boom} = (9\times3)2 & = \;\; 54 \\ \text{Bottom do.} = (9\times6)2 & = 108 \end{array} \right\} = 162.$$

Now we have here an increase in the material required for the booms accompanying the diminution in the value of N, and this deduction is borne out by other similarly treated examples, and might very readily mislead us, as it has already misled one writer, into thinking that there is an advantage to be gained by an increase in the number of the triangles above what would be the most economical were the material of the braces alone to be reduced to a minimum; *i. e.*, that θ should be diminished or a increased above 45°, the well-known economic angle for the braces when these are arranged in isosceles triangles. This erroneous view springs from the figures 1

FIG. 3.

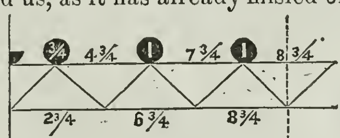
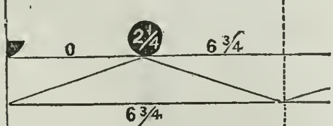


FIG. 4.



* These numbers have been omitted in some of the figures, but are all given in the detailed calculations of the booms.

and 2 not truly representing the conditions under which a uniform loading would be borne. The assumption that every one of the apices of the triangles receives an amount equal to W ÷ N is incorrect. A little consideration of the mode in which the loading is brought upon the points will convince us that the points immediately adjoining the piers receive each only three-quarters of the amount of the loading given up to each of the others, the other quarters being supported in a direct manner by the piers. The true conditions are therefore those shown by figures 3 and 4; and calculating the proportional quantities for the booms, as before, we have for

$$\begin{array}{l} \text{Fig. 3.} \\ \text{N} = 6 \end{array} \left\{ \begin{array}{ll} \text{Top} & = (4\tfrac{3}{4} \times 2 + 7\tfrac{3}{4} \times 2 + 8\tfrac{3}{4} \times 1)\,2 = 67{\cdot}5 \\ \text{Bottom} & = (2\tfrac{3}{4} \times 2 + 6\tfrac{3}{4} \times 2 + 8\tfrac{3}{4} \times 2)\,2 = 73{\cdot}0 \end{array} \right\} = 140{\cdot}5$$

$$\begin{array}{l} \text{Fig. 4.} \\ \text{N} = 2 \end{array} \left\{ \begin{array}{lr} \text{Top boom} = (6\tfrac{3}{4} \times 3)\,2 & = 40{\cdot}5 \\ \text{Bottom do.} = (6\tfrac{3}{4} \times 6)\,2 & = 81{\cdot}0 \end{array} \right\} = 121{\cdot}5$$

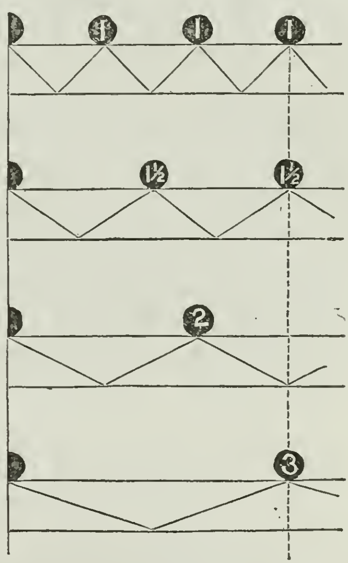
Here then we are led to an opposite deduction, and all similarly and correctly treated examples confirm it, viz: that a diminution in the material required for the booms to resist the longitudinal stresses accompanies a diminution in N; and consequently, if the consideration of the booms be admitted into the question, and the value of N be optional, the economic value of θ will be greater or that of α less than 45°.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.



When, as in the succeeding figures, the structure is suspended at the extremities of the upper member, and the loading spread uniformly over the top, then every apex will be loaded exactly to the extent of W ÷ N; so that with this arrangement of the structure, the error we have discussed above could never have been fallen into. The results for the figures 5 to 8 are as follow:

$$\begin{array}{l} \text{Fig. 5.} \\ \text{N} = 6 \end{array} \left\{ \begin{array}{ll} \text{Top} & = (2\tfrac{1}{2} \times 2 + 6\tfrac{1}{2} \times 2 + 8\tfrac{1}{2} \times 2)\,2 = 70 \\ \text{Bottom} & = (5 \times 2 + 8 \times 2 + 9 \times 1)\,2 = 70 \end{array} \right\} = 140.$$

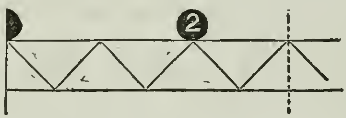
$$\begin{array}{l} \text{Fig. 6.} \\ \text{N} = 4 \end{array} \left\{ \begin{array}{llr} \text{Top} & = (3\tfrac{3}{8} \times 3 + 7\tfrac{7}{8} \times 3)\,2 & = 67{\cdot}5 \\ \text{Bottom} & = (6\tfrac{3}{4} \times 3 + 9 \times 1\tfrac{1}{2})\,2 & = 67{\cdot}5 \end{array} \right\} = 135.$$

$$\begin{array}{l} \text{Fig. 7.} \\ \text{N} = 3 \\ \theta = 63^\circ 26' \end{array} \left\{ \begin{array}{llr} \text{Top} & = (4 \times 4 + 8 \times 2)\,2 & = 64 \\ & & \\ \text{Bottom} & = (8 \times 4)\,2 & = 64 \end{array} \right\} = 128.$$

$$\begin{array}{l} \text{Fig. 8.} \\ \text{N} = 2 \end{array} \left\{ \begin{array}{ll} \text{Top} & = (4\tfrac{1}{2} \times 6)\,2 \qquad = 54 \\ \text{Bottom} & = (9 \ \times 3)\,2 \qquad = 54 \end{array} \right\} = 108.$$

So that we have here the same result as when the former figures 3 and 4 were correctly dealt with—a diminution of the material in the booms accompanying a diminished value of N. It would, however, be proceeding too hastily to conclude that the degree of slope of the braces directly affected the amount of material required for the booms. The fact is, we have not yet carried the analysis far enough; in the conversion of fig. 5 into fig. 7, two changes have been made: we have changed the value of the angle θ, but we have also changed the arrangement of the concentrated points of the loading, as well as the portion of the loading (= W ÷ N) which is in a direct manner imposed upon the piers. It remains, then, to discover what effect these changes will produce on the requisite material for the booms, when each is constrained to act independently of the other.

FIG. 9.



First, then, let us make such a change on the loading of fig. 5 as is exhibited in fig. 7, but without being complicated with a change in the angle θ; this we are enabled to do by adopting the arrangement shown in fig. 9, for the booms of which we have:

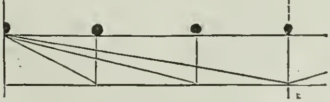
$$\begin{array}{l} \text{Fig. 9.} \\ \text{N} = 6 \\ \theta = 45^\circ. \end{array} \left\{ \begin{array}{ll} \text{Top} & = (2 \times 2 + 6 \times 2 + 8 \times 2)\,2 = 64 \\ \text{Bottom} & = (4 \times 2 + 8 \times 3)\,2 \qquad = 64 \end{array} \right\} = 128,$$

Which, when compared with the calculations for figs. 5 and 7, shows that the simple change of the arrangement of the loading is sufficient to account for all the difference in the results. But to make it still more clear that it is the change in the loading alone that causes the difference in the results, we add figs. 10, 11, and 12, in which the arrangement of the loading is retained exactly as in fig. 5, but the angle θ is very materially altered.

FIG. 10.

FIG. 11.

FIG. 12.



The results for these are:

$$\begin{array}{l} \text{Fig. 10.} \\ \text{N} = 6 \\ \theta = 63^\circ\, 26'. \end{array} \left\{ \begin{array}{ll} \text{Top} & = (2 \times 2 + 6 \times 2 + 8 \times 2)\,2 = 64 \\ \text{Bottom} & = (3 \times 2 + 7 \times 2 + 9 \times 2)\,2 = 76 \end{array} \right\} = 140.$$

$$\begin{array}{l} \text{Fig. 11.} \\ \text{N} = 6 \\ \theta = 63^\circ\, 26' \ \& \ 0. \end{array} \left\{ \begin{array}{ll} \text{Top} & = (5 \times 2 + 8 \times 2 + 9 \times 2)\,2 = 88 \\ \text{Bottom} & = (5 \times 2 + 8 \times 2)\,2 \qquad = 52 \end{array} \right\} = 140.$$

$$\begin{array}{r} \text{Fig. 12.} \\ N = 6 \\ \theta = 63^\circ\,26', \\ 75^\circ\,58', \\ \text{and } 80^\circ\,32'. \end{array} \left\{ \begin{array}{lll} \text{Top} & = (9 \times 6)\,2 & = 108 \\ & & \\ \text{Bottom} & = (2 \times 2 + 6 \times 2)\,2 = & 32 \end{array} \right\} = 140.$$

All of which results agree with that for fig. 5, so that we must come to the conclusion that the value of θ has no direct influence on the quantity of material required for the booms.

The saving in the booms from a reduction in the value of N must be chiefly caused by a larger portion of the load being deposited at once upon the piers. And this reduction of the load actually imposed upon the framing of the structure, must also, *cœteris paribus*, have an influence in reducing the material required for the braces. So that the economic angle for the braces considered alone would, if we might choose any value for N, come out somewhat greater than 45°. In structures such as figs. 1—4, the loading actually thrown upon the bracing is $= W - (W \div 2\,N)$, and in those like figs. 5—12, it is only $= W - (W \div N)$. In lattice bridges with many series, N (= the number of bays into which S is divided by the points of concentration of the loading) is very high, and then nearly the whole of W is supported by the framing.

When there is but one series of braces under the conditions of figs. 5—8, then D the depth being taken as the unit of length, and therefore $S \div D = S$, and the unit of load or stress being taken equal to the loading lying on a length of the span $= 2\,D$, $W = (S \div 2)$ units of weight. For such figures, *when N is an even whole number*, we have no difficulty in arriving at the following general formulæ for the proportional quantities of material required for the booms and braces, these quantities being represented all along by the stress multiplied by the length of each part. Let the proportional quantity for the booms be represented by B, that for the bracing by R, and that for the whole girder by $G = B + R$.

$$\text{N odd or even, } \left\{ B = \frac{W\,S^2}{6\,D} - \frac{W\,S^2}{6\,D\,N^2} = \frac{S^3}{12} - \frac{S^3}{12\,N^2}. \right. \qquad (1)$$

$$\text{N even, } \left\{ \begin{array}{ll} R = \frac{W}{2} N\,D \sec.^2\theta, \text{ but } \sec.^2\theta = \frac{S^2}{4\,N^2} + 1, & \\ \therefore = \frac{W\,S^2}{8\,N} + \frac{W\,N}{2} = \frac{S^3}{16\,N} + \frac{N\,S}{4}. & (2) \\ G = \frac{S^3}{12}\left(1 + \frac{3}{4}N - \frac{1}{N^2} + \frac{3\,N}{S^2}\right). & (3) \end{array} \right.$$

Differentiating the value of G with N as the variable, we have, after clearing the co-efficient, the following equation for G a minimum,

$$\tfrac{2}{3}\,S^2 = \tfrac{1}{4}\,S^2 N - N^3. \qquad (4)$$

Now to satisfy the premises, N must be an even whole number; let us therefore assign to it successively the values 4, 6, 8, 10, &c., the

resulting values of S will show the proportions of span to depth, which require *exactly* these values of N to produce the minima. The results, with the corresponding values of θ, are given in Table I.

TABLE I.

N =	4	6	8	10	12	14	16	100
S =	13·86	16·10	19·60	23·35	27·21	31·12	35·05	202·7
θ =	60° 0′	53° 18′	50° 46′	49° 25′	48° 35′	48° 1′	47° 37′	45° 23′

We may now take a particular value of S, say = 16·10 times the depth, and calculate the values of G by formula 3 to show what amount of extra material is incurred by departing from the most economical value of N (here = 6); and it will be observed from the results as given in Table II. that the variations in the values of G are surprisingly small, and would be still less so were R of its full value, as explained further on.

TABLE II.

$$S = 16{\cdot}10, \quad B = 347{\cdot}77 - \frac{347{\cdot}77}{N^2}, \quad \text{and } R = \frac{260{\cdot}83}{N} + 4{\cdot}025\,N.$$

N =	2 ?	4	6	8	10	12	16
B =	260·83	326·04	338·11	342·34	344·30	345 36	346·41
R =	138·46	81·31	67·62	64·80	66·33	70·04	80·70
G =	399 29	407·35	405·73	407·14	410·63	415 40	427·11
θ =	76° 3′	63° 35′	53° 18′	45° 10′	38° 50′	33° 51′	26° 35′

The case of N = 2 is exceptional; it does not satisfy, after the same manner as do the other values, the equation (4) by which Table I. is calculated, and in Table II. it produces a secondary minimum, the proper minimum being at N = 6.

It should be borne in mind that the variations in the values of B are produced solely by the variation of N, the number of points at which the loading is caused to concentrate or is supported, and that the value of θ has no direct influence on the value of B. Now if N be previously determined upon to suit the requirements of the roadway, suppose it to be = 16, then the corresponding value of B, = 346·41, is fixed, and unaltered by any value that may be assigned to θ; and, therefore, in such a case, the economic value of θ for the whole girder will be that which, under the particular conditions, gives the minimum for the bracing taken alone. When the bracing is of the isosceles character, the minimum of the bracing will accompany the nearest practicable approach to the case of $\theta = 45°$. So that for N = 16 and S = 16·10, Table II., instead of using $\theta = 26° 35'$, with R = 80·7, when one series of braces only is admitted, we may adopt a form in which there would be two series, having a prevailing angle $\theta = 45° 1'$, except at the ends, where it may be necessary to combine the two series into one, to satisfy the conditions.

In the above calculations, R as compared with B is undervalued, in the first place, because the material of the bracing as there estimated is such as would be required for a uniformly distributed *constant* loading. But when the loading is wholly or partially a movable one, the amount of material for the braces becomes increased, without, however, affecting the value of B in the least. Again, the allowance of material in proportion to stress would in practice be greater for the braces than for the booms. But this part of the question is not of that importance that we need dwell at greater length upon it here.

The conclusions that we have arrived at are:

1. When the loading and the bearings on the piers are on one level (or, in other words, when there is a full-lengthed bay adjoining each pier), and only one isosceles system of braces, as in figs. 5 to 8, and when the number of points in the span to be supported by the bracing may be of any number,—the lightest structure will be produced by a certain low value of N dependent upon the value of S ÷ D, as shown in Table I. But, on the other hand, as shown by Table II., the variation produced in the total weight of the girder by varying the value of N, is very slight, and therefore that value would be chosen which gave a sufficiently liberal number of supports to the roadway.

2. When N is fixed or previously determined upon, but the points of support on the piers, the number of series, and the arrangement of the braces, are all left optional (as in figs. 5, 10, 11, and 12), the greatest economy will be secured by causing θ to approximate to a certain economic value, to be determined for the particular kind of bracing and materials to be employed. The minimum for the bracing taken alone having in this case to be considered.

In our next, we shall discuss the economic values of θ for various forms of bracing, and draw comparisons to show their relative costs.

R. H. B.

EDINBURGH.

New Westminster Bridge.

From the Civ. Eng. and Arch. Jour., March, 1862.

It is expected by Mr. Page, the engineer, that the whole roadway of the new bridge at Westminster will be finished in May next. The last vestiges of the old structure have now been dredged out, and all the arches of the remaining half, save the fifth and sixth, are completed. The two latter will have their crowns of wrought iron girders bolted in in a few days, and as fast as each is placed, the buckle plates for the roadway will go down. Over these plates, comes a packing of blocks of pine wood and asphalte, and over all the stone pitching pavement of the road. Up to the present, the eastern half has been entirely disconnected from that which is finished. It is now being joined by a number of short cross girders or stay pieces of cast iron, and over these, as soon as the timber scaffolding is removed, the plates and roadway will be laid, so as to form one complete structure of the two halves. When the two are connected into one rigid mass, it is expect-

ed that the vibration now experienced on the western and smaller half will entirely disappear. Before the bridge can be opened, however, the half that is now finishing and closed must be entirely complete. A very broad foot pavement will be laid down, with small handsome terra-cotta tiles, cross-barred in contrary directions, to give firm foothold, and these are to be edged in with a kerb of red granite. These terra-cotta tiles are coming much into use. It is stated, as the result of experience, that they are better, drier, more easily repaired, and more durable for passenger traffic than granite itself. It has been decided to place the tramways for heavy traffic to and fro in the centre of the bridge, leaving two roadways of 20 feet wide on each side for the lighter vehicles. The side next the Houses of Parliament is completely finished, except some ornamental shields, that can be bolted into the Gothic quatrefoil spandrils of the arches at any moment. From this point, therefore, the effect of the whole structure can well be judged. The conventional street lamp-post will not intrude upon this thoroughfare, as handsome lamps and posts of cast iron have been designed, in keeping with the main architectural features of the rest of the work, and all the iron portions of it are to be painted of a pale neutral tint, excepting only the ornamental shields before spoken of, which will be emblazoned with the arms of England and Westminster, in gold and enduring colors. Since the western half has been opened for traffic, not the slightest sinking of the piers has taken place. When the entire bridge is finished, there will be two footways of 15 feet wide each, two tramways in the centre of 7 feet 6 inches wide, and two roadways for the light traffic of 20 feet each. The extreme width of London Bridge is only 56 feet from parapet to parapet, or exactly the space of the roadway of the new bridge exclusive of footpaths. When all is complete, the bed of the river is to be dredged out of rubbish, &c., some 10 or 12 feet below its present level beneath the new arches. In a month or two more, for the first time within the last twenty years, the tide will flow unimpeded up and down the Thames.

Preservation of Stone.

From the Lond. Mechanics' Magazine, February, 1862.

At a recent meeting of the Architectural Association, Mr. A. H. Church read a paper "On the Preservation of Stone." The author treated the subject chiefly from a chemical point of view, describing, first, the nature and causes of those injuries suffered by stone against which it is our object to guard. Under this division he spoke of the *weathering* of rocks, and of the natural agents of destruction with which building stone has to contend, and also of the more rapid injurious influences of artificial origin. He showed how far the destructive actions of water, carbonic, sulphurous, and sulphuric acids, &c., were chemical, and how far mechanical.

In the second part of the paper, the following principles were laid down as being likely, when carried into practice, of accomplishing the end in view:—

1. Any process to be thoroughly effectual in arresting or preventing the decay of building stones, must be easy of application, and moderate in cost.

2. It must render absorbent stone less porous, and at the same time counteract the influence of injurious bodies in the air.

3. It must effect the consolidation of stones in which the particles are loosely aggregated, and it must harden stones easily abraded by slight mechanical means.

4. The color, surface, and texture of the stone, must not be materially altered by the process.

5. The protective material must not be a mere film, but must penetrate to some depth; nor must it be liable to such contraction of the surface as shall cause a separation of particles from the stone.

6. The protective material must be less soluble in water, and less amenable to injurious atmospheric influences than the original materials of the stone.

7. No soluble salt, especially no effervescent or crystallizing salt, must remain in the stone as one of the products of the protective process.

The author, in treating thirdly of actual processes, arranged them in classes, and pointed out how far most of them were from fulfilling the necessary conditions of success. Imagine the absurdity of applying to stone as a preservative material a preparation like starch paste, itself undergoing in the course of a few days a most offensive decomposition. Such a plan with many others less palpably, but not less really, unsuitable, has actually been proposed.

Lastly, some of the results of an examination, chemical, physical, and microscopical, into the results of several of these processes were detailed. One of the most curious of these results was the effect produced on stones by the efflorescence of sulphate of soda or sulphate of magnesia upon their surface. The formation of such salts is actually favored by some of the so-called preservative processes; and it is remarkable to note upon the summit of each hair-like crystal a minute fragment of stone torn off and carried forward by the force of the crystallization. Another singular phenomenon was described as occurring when a strong solution of silica in water is applied to chalk or any soft limestone. The silica glutinizes on the surface; the film thus formed separates into small scales, and, as these fall off, it will be noticed that their under surfaces are covered with minute adherent particles of the stone or chalk.

The Acoustic Properties of Rooms.

From the London Builder, No. 961.

I think it must be admitted that sound, having its laws, is affected by the proportions of the room wherein it is emitted; consequently, a building of a certain height, length, breadth, form, and arrangement in its details, is required to enable an assemblage of persons to

hear clearly and distinctly in every part of the room. Now, I have no doubt but your numerous correspondents are able to point out many buildings which they consider as good examples in this respect; but for myself, I only know of *one room* (and I have been in many throughout the kingdom) which I consider as near perfection as possible, and that is the concert room of the Cheltenham Pump-room, Harrogate; and, being desirous of contributing my small mite of information for the benefit of those who may be pleased to make use of it, and also for the purpose of stimulating further inquiry and investigation on this important subject, I have procured from Mr. Whitehead, of Harrogate, the exact dimensions, &c., of this room, which was built in 1833, from the designs of Mr. Clark, of Leeds, and contains the following dimensions:—

	Ft.	ins.
Length of room inside, . .	86	6
Width of room, . .	33	0
Height to ceiling line, . .	22	7
Ditto to centre, . .	24	2

The ceiling is a segment of a circle rising 1 foot 7 inches. There are nine sunk panels in the length of the ceiling, and seven in width: these are 9 inches deep. There are nine large windows along the north wall, three windows at the east end, the same at the west entrance, and on the south wall there are two doors and one window, a small orchestra about 10 feet high, and two noble $\frac{3}{4}$ Doric columns on each side of this orchestra, projecting 1 foot 6 inches from the wall.

T. B.

MECHANICS, PHYSICS, AND CHEMISTRY.

On the Strength of Steel containing different proportions of Carbon. By Mr. T. Edward Vickers, of Sheffield.

From Newton's London Journal, March, 1862.

Three most important materials of British manufacture—wrought iron, steel, and cast iron—are combinations of iron with a smaller or larger amount of carbon. Wrought iron contains from about $\frac{1}{8}$ to $\frac{1}{2}$ per cent. of carbon, cast steel about $\frac{3}{8}$ to 2 per cent., and cast iron from $2\frac{1}{2}$ to 7 per cent. The great variety of opinions that have been expressed respecting the strength of steel when containing different proportions of carbon, led the writer to make a number of tests upon this point, the results of which are given in the present paper, with the conclusions derived from them.

The degree of carbonization in the several varieties of steel tested in the experiments ranged from about $\frac{1}{3}$ per cent. of carbon to $1\frac{1}{4}$ per cent.; the softest or least carbonized steel containing $\frac{1}{3}$ per cent. of carbon was called No. 2, and the hardest and most highly carbonized, containing $1\frac{1}{4}$ per cent. of varbon, No. 20; the intermediate numbers representing intermediate degrees of carbonization. The tests to which the steel was subjected consisted in ascertaining its tensile strength, by

means of bars of the steel broken by direct tension, and also its transverse strength, by means of axles made of the steel which were broken by the blows of a heavy ram.

Tensile Strength.—The tensile strength of the several varieties of steel was tested by a simple lever machine, in which the leverage is 220 inches to 11 inches, or 20 to 1, so that each cwt. added in the scale at the long end of the lever, produces a tension of 1 ton on the test bar at the other end of the lever. The test bars were $21\frac{1}{2}$ inches long, with 14 inches of their length turned down to a uniform diameter of 1 inch. For facility of fixing the bars in the testing machine, and removing them when broken, the ends were made wedge-shaped, and the lower end was held in a conical socket in the holding down block, into which it was inserted through a longitudinal slot; the bar was then turned half round, and the upper end slipped into a wedge-shaped holder at top, whereby the bar was securely held during the testing. The following table gives the results of the trials, showing the breaking strain reduced to tons per square inch, together with the amount of elongation produced in the bars. The elongation was measured after each addition of load in the scale at the long end of the lever; and that given in the table is the final amount of elongation, previous to adding the last cwt. in the scale which caused the breakage.

Tensile Strength of Steel, containing different proportions of Carbon.

Description of Steel.	Proportion of Carbon (approximate).*	Breaking Strain Per square inch.	Elongation.
	Per cent.	Tons.	Inches.
No. 2	0·33	30·4	1·37
No. 4	0·43	34·0	1·37
No. 5	0·48	37·5	1·25
No. 6	0·53	42·5	1·12
No. 7	0·58	41·5†	0·81
No. 8	0·63	45·0	1·00
No. 10	0·74	45·5	0·69
No. 12	0·84	55·0	1·12
No. 15	1·00	60·0	1·00
No. 20	1·25	69·0	0·62

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

† There was a flaw in this test bar, which will account for its breaking at a lower strain than the preceding No.

The table shows, that the tensile strength of the steel is increased by the addition of carbon, until it is combined with about $1\frac{1}{4}$ per cent. of carbon, when it sustains about 69 tons per square inch. But beyond this degree of carbonization, the steel becomes gradually weaker, until it reaches the form of cast iron, which sustains a tensile strain of only about 6 or $6\frac{1}{2}$ tons per square inch. When the test bar is turned down at one point only, instead of through a considerable length, the result obtained has been found to be different: for a bar of steel turned down to $\frac{3}{4}$ inch diameter at one point only, did not break till the strain reached $79\frac{1}{2}$ tons per square inch; whereas a bar of the

same steel, turned down to 1 inch diameter for 14 inches of its length, broke with a tension of 60 tons per square inch.

Transverse Strength.—For testing the transverse strength of the several varieties of steel, axles were made of the steel in the various degrees of carbonization, which were subjected to the blows of a heavy ram until broken. The axles were all turned to 3·94 inches diameter at the centre, and 4·25 inches at the ends, and were supported on bearings 3 feet apart; they were reversed at intervals, when considerably bent by the blows of the ram. The ram weighed 1547 lbs. or nearly 14 cwts., and was dropped on the centre of the axle from a height commencing at 1 foot, and increasing at each successive blow, up to 36 feet fall, unless the axle was broken at a previous blow.

A table was appended, giving the detail of the experiment on an axle of No. 4 steel, containing about $\frac{4}{10}$ per cent. of carbon; showing that it stood 5 blows of the ram, falling from 36 feet height, before breaking, after 12 blows from lower heights of fall—the sum of all the deflections produced by the blows amounting to 56 inches.

Another table gave the general results of the series of experiments, made in a similar manner, with axles of the several varieties of steel; showing the total number of blows required to break each axle, the number that it sustained with 36 feet fall of the ram before breaking, and the sum of all the deflections produced. Three wrought iron axles were also tried in the same way,—one of the best fagoted axles that could be procured, and two scrap iron axles.

From these experiments, it appeared that, for bearing sudden and heavy blows, without regard to rigidity, the metal cannot contain too little carbon, provided it be pure and there be perfect cohesion of the particles. These qualities, however, cannot exist to the required degree in wrought iron or puddled steel; and are to be found only in cast steel, which must contain at least enough carbon to render it sufficiently fluid in melting. The steel melting process alone can effectually rid the metal of the impurities that were contained in the iron from which it is made.

There is nothing more deleterious to iron or steel than over-heating or too many heatings, and the writer believes that all welding affects the quality of the metal more or less injuriously. Cast steel has the great advantage of being less liable than any other metal in general use to become crystallized by vibration. It has already a natural crystal, and the result of the writer's experience is that its crystal can be changed into a weak form only by being over-heated. Cast steel and Swedish wrought iron have been placed where they were subjected equally to continual blows, concussions, and vibrations; and the cast steel was found to stand for a long period without change of crystal, where the Swedish iron broke very soon, showing great changes in its form of crystallization.

For most mechanical purposes, the best material in practice is one that combines the power of resisting a tolerably high tensile as well as transverse strain; one that will bear a tension of about 45 to 50 tons per square inch will generally be quite strong enough, and will be below

the point at which brittleness from too great rigidity begins. The following table gives a comparison of the first and third tables, and shows that such a material is found in the steel, Nos. 8 to 10, containing about $\frac{5}{8}$ to $\frac{3}{4}$ per cent. of carbon. There are, of course, purposes where a specially ductile or specially rigid material should be employed, but the latter should be used only in cases where it is not liable to be subjected to sudden concussions.

Transverse and Tensile Strength of Steel, containing different proportions of Carbon.

Description of Steel.	Proportion of Carbon (approximate).*	TRANSVERSE.	TENSILE.	
		Sum of Deflections.	Breaking Strain per square inch.	Elongation.
	Per cent.	Inches.	Tons.	Inches.
No. 2	0·33	58·81	30·4	1·37
No. 4	0·43	56·00	34·0	1·37
No. 5	0·48	53·56	37·5	1·25
No. 6	0·53	35·06	42·5	1·12
No. 7	0·58	38·81	41 5	0·81
No. 8	0·63	46·00	45·0	1·00
No. 10	0·74	40·31	45·5	0·69
No. 12	0·84	8·56	55·0	1.12
No. 15	1·00	4·31	60·0	1·00
No. 20	1·25	6·94	69·0	0·62

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

The superior strength of cast steel cannot be better illustrated than by stating that castings of steel, without hammering, rolling, or other means of mechanical compression, show a very high degree of strength and tenacity, far above that of castings of any other metal in practical use. Advantage is taken of this property to make bells of cast steel one-third lighter than bronze bells of the same diameter; and these lighter steel bells still bear double the breaking strain of the bronze ones. Another feature in the superior strength of castings in steel is, that they are not so liable as other metals to break when subjected to concussions during intense frost, as proved by the fact that the cast steel bells have been rung without the least injury in Russia and in Canada, when the thermometer ranged lower than 20° below zero Fahr.; while the heavier and thicker bronze bells could not be rung in the same temperature without cracking.

The same properties have also led to the manufacture of cast steel disk wheels with tyres in one solid body, for railway carriages and engines. One of these disk wheels was thus tested. The wheel was put upon an axle fixed firmly in bearings at each end, and a ball weighing 830 lbs., or nearly $7\frac{1}{2}$ cwts., suspended by an iron rod 24 feet long, was drawn back and let fall so as to strike the wheel on the outside of the rim or tyre. The wheel was struck nine blows, increasing from one foot to fourteen feet in vertical height of fall, after which the axle was so much bent that the ball could not strike the wheel. The axle was then straightened by striking the wheel on the opposite side, and was

propped up to prevent bending again; and two more blows were struck from the height of 15 and 16 feet, without causing any damage to the wheel.

The results of all the experiments that have been described show that cast steel, which even to the present time is considered by many a brittle material, fit only for a cutting instrument, is in fact a metal having not only all the good and desirable properties of wrought iron in a higher degree, but at the same time freedom from most of the objectionable properties of the latter, and admitting of being employed for every mechanical purpose where great ductility, tenacity, and transverse strength are required.

In reference to the specific gravity of steel as affected by the proportion of carbon it contains, chemists and scientific writers have generally given the specific gravity of steel as about 7·850, and of wrought iron about 7·650,—that of water being 1·000; which leads to the inference that the addition of carbon to iron has the effect of increasing its density, and such is the general opinion at present. The contrary, however, has been found by the writer to be the fact, namely, that pure iron decreases in density the more carbon there is combined with it. The low specific gravity of wrought iron above stated, must therefore have been obtained from common English merchant iron, a piece of which gave a specific gravity of 7·644, which very nearly agrees with that abovementioned; and must be owing to the impurities contained in the iron. The specific gravity of one of the purest and softest Swedish irons is 7·894; and that of the iron from which the steel was made for all the experiments that have been described above is about 7·860. A table, appended to the paper, gives the specific gravities as ascertained by experiment of the successive gradations of steel, from No. 2, containing about $\frac{1}{3}$ per cent. of carbon, up to No. 20, containing about $1\frac{1}{4}$ per cent., the results having been all obtained with pieces of metal of considerable size, varying from $2\frac{3}{4}$ to $4\frac{1}{2}$ ozs. in weight.

The specific gravities of the steel No. 2 and 4 appeared to be greater than that of the original iron; but this may be attributed to the iron being freed from impurities in the melting. The conclusion therefore derived from the tabulated figures is, that every successive addition of carbon to pure iron renders the metal less dense or diminishes its specific gravity.

Mr. Vickers exhibited a number of strips of steel plate $\frac{5}{16}$ inch thick, which had been tested to show how far they could each be bent before cracking, when containing different proportions of carbon. Also a large cast steel pinion, and one of the steel axles that had been tested. After testing the axles, he had rolled down the broken pieces into plates $\frac{5}{16}$ inch thick, and tried them by bending, as shown by the other specimens exhibited. The softest steel, called No. 2 in the tables of experiments, had a tensile strength of only 30 tons per sq. inch, but the test plate made of it bore bending double without cracking, showing a great degree of toughness; while the most highly carbonized

quality, No. 20, had the greatest tensile strength, amounting to 69 tons per sq. inch, but was so brittle that it snapped asunder without bending more than about 45° out of the straight line. For the experiments on axles, in order to obtain the most correct results from wrought iron axles for comparison with those of steel, he got the best wrought iron axle he could of the regular fagoted make from a railway company, and also two scrap axles from makers who knew they were going to be tested; but the last two turned out worse than had been expected, and much inferior to the first.

One circumstance to be noticed respecting the mode of testing the tensile strength of bars was, that the results obtained with long test bars were different from those given by short ones. In a number of experiments upon this point he had found it to be regularly the case, that if the test bar were turned down to the required diameter at one point only of its length, it would stand one-third more strain than if turned down to the same diameter throughout a length of 14 inches. This was a fact of much importance, as affecting the value of many experiments.

Mr. H. Maudslay observed, that in turning down a long length of the test bar, each part of that length was subjected to the strain, and therefore the test was exposed to all the chances of weak places occurring from irregularity in make of the bar at any point of its length; but when the bar was turned down at one part only, the chance of breaking at a weak place was confined to that small length only.

Mr. Vickers thought the result could not be merely an average of chances, for he had noticed that the bar was always stronger when turned down at one point only, in the manner described. He thought it might arise from the strain producing a greater effect in stretching the bar and reducing its diameter when turned down of uniform diameter for a long length, since steel always stretched considerably before breaking. The breakage occurred, however, at various points in the length turned down—not at the centre only.

In answer to an inquiry of the Chairman, Mr. Vickers stated that steel axles were used almost universally on the German railways, and also steel tyres and wheels. A number of the steel axles of the make now shown were in use there, and some of the cast steel wheels. Very few steel axles had yet been tried in England, but many steel tyres were now used.

Mr. E. Riley asked what iron the steel was made from, and how far it was free from carbon in its original state previous to being converted into steel.

Mr. Vickers said, the iron used was Swedish iron, which he had tested previously, and believed to be as free from carbon as possible.

Mr. E. Riley doubted the freedom of the iron from carbon, and believed a small quantity of carbon was essential in wrought iron, without which it was useless. From experiments he had made he had found that the best wrought iron, after being melted, was always red-short, and would not work at all, but was useless as wrought iron; and con-

sidered this was due to its being deprived of the small per centage of carbon it contained, by the scale on its surface and the air in the melting pot. He had also found experimentally that fused wrought iron from the best ores was red-short and useless when made by reducing them with too small an amount of carbon, so as to leave oxide of iron in the cinder, which prevented any carbon from combining with the iron. This defect, however, was easily remedied by adding carburet of manganese, which supplied the requisite amount of carbon; and, moreover, the oxide of manganese acted also as a useful flux in separating some of the impurities contained in the iron: the addition of 1 per cent. of carburet of manganese to fused wrought iron made the iron work well, and prevented its being red-short.

The Chairman knew no question of so much importance to engineers as the effect of carbon on iron and steel, since the various qualities of both depended mainly on the proportion of carbon combined with them. A haze of doubt still hung over the subject, and called for further investigations to clear it away; but the period was now dawning when iron would be used in the form of mild cast steel, and an age of steel appeared likely to supersede that of iron. Tabulated experiments giving definite results, such as those in the paper, were the most efficient means of solving the question; and such information placed in the hands of engineers was of special value in enabling them to draw their own conclusions from the results obtained.

Proceedings Insti. Mech. Engineers, July 31, 1861.

Long Tube Barometer.

From the London Mechanics' Magazine, December, 1861.

After a recent meeting of the Institute of Civil Engineers, Mr. R. Howson exhibited in the library a Barometer, consisting of a long tube freely suspended open end downwards, a cistern which was of a tubular shape, and a "stalk." The stalk was a glass tube, sealed at both ends, attached firmly at its lower end to the bottom of the cistern, and rising axially up the tube until it nearly reached the surface of the mercurial column. The consequence of this arrangement was, that the top of the stalk came into the region of very low pressure, and there was an excess of pressure tending to force the cistern upwards. This excess was represented by the weight of the cistern (and stalk), and the contained mercury, so that under a given atmospheric pressure, the cistern would always hang suspended at a given level. When the pressure of the atmosphere rose, a portion of mercury left the cistern and passed into the tube, and the cistern also arose, until the level was replaced by the immersion of the glass which formed the tube. When the pressure fell, the converse took place. An elongated scale was thus produced, the extent of range being dependent upon the relative areas of the tube, and of the glass which composed it. The action might also be simply viewed as that of a long piston, or plunger, with a liquid packing, having a vacuum on its upper side, and a self-graduating weight attached to its lower side.

Reading the Barometer.

From Mitchell's Steam-shipping Journal, No. 57.

The following manual of the barometer has been compiled by Rear Admiral Fitzroy, and published by the Board of Trade:—

Familiar as the practical use of weather-glasses is, at sea as well as on land, only those who have long watched their indications and compared them carefully are really able to conclude more than that the rising glass* usually foretells less wind or rain, a falling barometer more rain or wind, or both; a high one fine weather, and a low the contrary. But useful as these general conclusions are in most cases, they are sometimes erroneous, and then remarks may be rather hastily made, tending to discourage the inexperienced.

By attention to the following observations (the results of many years practice and many persons experience), any one not accustomed to use a barometer may do so without difficulty.

The barometer shows whether the air is getting lighter or heavier, or is remaining in the same state. The quicksilver falls as the air becomes lighter, rises as it becomes heavier, and remains at rest in the glass tube while the air is unchanged in weight. Air presses upon everything within about 40 miles of the world's surface like a much lighter ocean, at the bottom of which we live, not feeling its weight, because our bodies are full of air,† but feeling its currents, the winds. Towards any place from which the air has been drawn by suction,‡ air presses with a force or weight of nearly 15 lbs. on a square inch of surface. Such a pressure holds the limpit to the rock when, by contracting itself, the fish has made a place without air§ under its shell. Another familiar instance is that of the fly, which walks on the ceiling with feet that stick. The barometer tube, emptied of air, and filled with pure mercury, is turned down into a cup or cistern containing the same fluid, which feeling the weight of air, is so pressed by it as to balance a column of about 30 inches (more or less) in the tube, where no air presses on the top of the column.

If a long pipe, closed at one end only, were emptied of air, filled with water, the open end kept in water, and the pipe held upright, the water would rise in it more than 30 feet. In this way water barometers have been made. A proof of this effect is shown by any well with a sucking pump, up which, as is commonly known, the water will rise nearly 30 feet by what is called suction, which is, in fact, the pressure of air towards an empty place.

The words on scales of barometers should not be so much regarded for weather indications as the rising or falling of the mercury, for if it stand at "changeable," and then rise towards "fair," it presages a change of wind or weather, though not so great as if the mercury had risen higher; and, on the contrary, if the mercury stand above "fair," and then fall, it presages a change, though not to so great a degree as

* Glass, barometer, column, mercury, quicksilver, or hand.
† Or atmosphere, or the atmospheric fluid which we breathe.
‡ Or exhaustion. § A vacuum.

if it had stood lower; besides which, the direction and force of wind are not in any way noticed. It is not from the point at which the mercury may stand that we are alone to form a judgment of the state of the weather, but from its rising or falling, and from the movements of immediately preceding days as well as hours, keeping in mind effects of change of direction and dryness or moisture, as well as alteration of force or strength of wind.

In this part of the world, towards the higher latitudes, the quicksilver ranges, or rises and falls, nearly three inches—namely, between about thirty inches and nine-tenths (30·9) and less than twenty-eight inches (28·0) on extraordinary occasions; but the usual range is from about thirty inches and a half (30·5) to about twenty-nine inches. Near the Line, or in equatorial places, the range is but a few tenths, except in storms, when it sometimes falls to twenty-seven inches.

The sliding scale (vernier) divides the tenths into 10 parts each, or hundredths of an inch. The number of divisions on the vernier exceeds that in an equal space of the fixed scale by one.

By a thermometer the weight of air is not shown. No air is within the tube; none can get in. But the bulb of the tube is full of mercury, which contracts by cold and swells by heat, according to which effect the thread of metal in the small tube is drawn down or pushed up so many degrees, and thus shows the temperature.*

If a thermometer have a piece of linen round the bulb, wetted enough to keep it damp by a thread or wick dipping into a cup of water, it will show less heat than a dry one, in proportion to the dryness of the air and quickness of drying.† In very damp weather, with or before rain, fog, or dew, two such barometers will be nearly alike.

For ascertaining the dryness or moisture of air, the readiest and surest method is the comparison of two thermometers, one dry, the other just moistened and kept so. Cooled by evaporation as much as the state of the air admits, the moist (or wet) bulb thermometer shows a temperature nearly equal to that of the other one when the atmosphere is extremely damp or moist; but lower at other times, in proportion to the dryness of air and consequent evaporation—as far as 12 or 15 degrees in this climate, 20 or even more elsewhere. From four to eight degrees of difference is usual in England, and about seven is considered healthy for inhabited rooms.

The thermometer fixed to a barometer intended to be used only as a weather glass shows the temperature of air about it nearly, but does not show the temperature of mercury within exactly. It does so, however, near enough for ordinary practical purposes, provided that no sun, nor fire, nor lamp heat is allowed to act on the instrument partially.

The mercury in the cistern and tube being affected by cold or heat, makes it advisable to consider this when endeavoring to foretell coming weather by the length of the column.

Briefly, the barometer shows weight or pressure of the air; the

* Thirty-two degrees is the point at which water begins to freeze or ice to thaw.

† Evaporation.

thermometer, heat and cold, or temperature; and the wet thermometer, compared with a dry one, the degree of moisture or dampness.*

It should always be remembered that the state of the air foretells coming weather, rather than shows the weather that is present—an invaluable fact too often overlooked; that the longer the time between the signs and the change foretold by them, the longer such altered weather will last; and, on the contrary, the less the time between a warning and a change, the shorter will be the continuance of such foretold weather.

To know the state of the air, not only barometers and thermometers should be watched, but the appearances of the sky should be vigilantly noticed.

If the barometer has been about its ordinary height, say near 30 inches (at the sea level),† and is steady, or rising, while the thermometer falls, and dampness becomes less, north-westerly, northerly, or north-easterly wind, or less wind, less rain or snow may be expected.

On the contrary, if a fall takes place with a rising thermometer and increased dampness, wind and rain may be expected from the south-eastward, southward, or south-westward.

A fall with a low thermometer foretells snow.

Exceptions to these rules occur when a north-easterly wind, with wet (rain, hail, or snow), is impending, before which the barometer often rises (on account of the direction of the coming wind alone), and deceives persons who from that sign only (the rising) expect fair weather.

When the barometer is rather below its ordinary height—say down to near 29½ inches (at the sea level)—a rise foretells less wind, or a change in its direction towards the northward, or less wet; but when it has been very low, about 29 inches, the first rising usually precedes or indicates strong wind; at times heavy squalls from the north-westward, northward, or north-eastward—after which violence a gradually rising glass foretells improving weather if the thermometer falls; but if the warmth continue, probably the wind will back (shift against the sun's course), and more southerly or south-westerly wind will follow, especially if the barometer rise is sudden.

The most dangerous shifts of wind, or the heaviest northerly gales, happens soon after the barometer first rises from a very low point; or, if the wind veers gradually, at some time afterwards.

Indications of approaching changes of weather and the direction and force of winds are shown less by the height of the barometer than by its falling or rising. Nevertheless, a height of more than thirty (30·0) inches (at the level of the sea) is indicative of fine weather and moderate winds; except from east to north occasionally.

The barometer is said to be falling when the mercury in the tube is sinking, at which time its upper surface is sometimes concave or hollow; or when the hand moves to the left. The barometer is rising

* The two thus combined make a hygrometer, for which some kinds of hair, grass, or seaweed may be a make-shift.

† It differs, or stands lower, about a tenth of an inch for each hundred feet of height directly upwards, or vertically, above the sea; its average height being 29·94 inches at the mean sea level in England. Allowances must, therefore, be made for barometers on high land or in buildings.

when the mercurial column is lengthening; its upper surface being convex or rounded, or when the hand moves to the right.

A rapid rise of the barometer indicates unsettled weather; a slow movement the contrary; as likewise a steady barometer, which, when continued, and with dryness, foretells very fine weather.

A rapid and considerable fall is a sign of stormy weather and rain (or snow). Alternate rising and sinking indicates unsettled and threatening weather.

The greatest depressions of the barometer are with gales from S. E., S., or S. W.; the greatest elevations, with wind from N. W., N., or N. E., or with calm.

Though the barometer generally falls with a southerly and rises with a northerly wind, the contrary sometimes occurs; in which cases, the southerly wind is usually dry with fine weather, or the northerly wind is violent and accompanied by rain, snow, or hail; perhaps with lightning.

When the barometer sinks considerably, much wind, rain (perhaps with hail), or snow will follow; with or without lightning. The wind will be from the northward, if the thermometer is low (for the season) —from the southward, if the thermometer is high. Occasionally a low glass is followed or attended by lightning only, while a storm is beyond the horizon.

A sudden fall of the barometer, with a westerly wind, is sometimes followed by a violent storm from N. W., or N., or N. E.

If a gale sets in from E. or S. E., and the wind veers by the S., the barometer will continue falling until the wind is near a marked change, when a lull *may* occur; after which the gale will soon be renewed, perhaps suddenly and violently, and the veering of the wind towards the N. W., N., or N. E. will be indicated by a rising of the barometer with a fall of the thermometer.

Three causes (at least)* appear to affect a barometer:—

1. The direction of the wind—the north-east wind tending to raise it most—the south-west to lower it the most, and wind from points of the compass between them proportionally as they are nearer one or the other extreme point.

N. E. and S. W. may therefore be called the wind's extreme bearings (rather than poles).

The range or difference of height shown, due to change of direction only, from one of these bearings to the other (supposing strength or force, and moisture to remain the same), amounts in these latitudes to about half an inch (as read off).

2. The amount—taken by itself—of vapor, moisture, wet, rain, or snow in the wind, or current of air (direction and strength of wind remaining the same), seems to cause a change amounting in an extreme case to about half an inch.

3. The strength or force alone of wind, from any quarter (moisture and direction being unchanged), is preceded or foretold by a fall or

* Electrical effects are yet uncertain.

rise, according as the strength will be greater or less, ranging in an extreme case to more than two inches.

Hence, supposing three causes to act together—in extreme cases—the height would vary from near 31 inches (30·9) to about 27 inches (27·0), which has happened, though rarely (and even in tropical latitudes).

In general, the three causes act much less strongly, and are less in accord; so that ordinary varieties of weather occur much more frequently than extreme changes.

Another general rule requires attention; which is, that the wind usually appears to veer, shift, or go round with the sun (right-handed, or from left to right),* and that when it does not do so, or backs, more wind or bad weather may be expected instead of improvement.

It is not by any means intended to discourage attention to what is usually called "weather wisdom." On the contrary, every prudent person will combine observation of the elements with such indications as he may obtain from instruments; and will find that the more accurately the two sources of foreknowledge are compared and combined, the more satisfactory their results will prove.

A barometer begins to rise considerably before the conclusion of a gale, sometimes even at its commencement. Although it falls lowest before high winds, it frequently sinks very much before heavy rain. The barometer falls, but not always, on the approach of thunder and lightning.† Before and during the earlier part of settled weather it usually stands high and is stationary, the air being dry.

Instances of fine weather with a low glass occur, however, rarely, but they are always preludes to a duration of wind or rain, if not both.

After very warm and calm weather, a storm or squall, with rain, may follow; likewise at any time when the atmosphere is heated much above the usual temperature of the season.

Allowance should invariably be made for the previous state of the glasses during some days, as well as some hours, because their indications may be affected by distant causes, or by changes close at hand. Some of these changes may occur at a greater or less distance, influencing neighboring regions, but not visible to each observer whose barometer feels their effect.

There may be heavy rains or violent winds beyond the horizon, and the view of an observer, by which his instruments may be affected considerably, though no particular change of weather occurs in his immediate locality.

It may be repeated that the longer a change of wind or weather is foretold before it takes place, the longer the presaged weather will last; and, conversely, the shorter the warning the less time, whatever causes the warning, whether wind or a fall of rain or snow, will continue.

Sometimes severe weather from the southward, not lasting long,

* With watch-hands in the northern hemisphere, but the contrary in south latitude. This, however, is only apparent; the wind is actually circulating in the contrary direction.

† Thunder-clouds rising from north-eastward, against the wind, do not usually cause a fall in the barometer.

may cause no great fall, because followed by a duration of wind from the northward, and at times the barometer may fall with northerly winds and fine weather, apparently against these rules, because a continuance of southerly wind is about to follow. By such changes as these one may be misled, and calamity may be the consequence, if not duly forewarned.

A few of the more marked signs of weather, useful alike to seaman, farmer, and gardener, are the following:—

Whether clear or cloudy—a rosy sky at sunset presages fine weather; a red sky in the morning bad weather, or much wind (perhaps rain); a grey sky in the morning, fine weather; a high dawn, wind; a low dawn, fair weather.*

Soft-looking or delicate clouds foretell fine weather, with moderate or light breezes; hard edged, oily-looking clouds, wind. A dark, gloomy, blue sky is windy; but a light, bright blue sky indicates fine weather. Generally, the softer clouds look, the less wind (but perhaps more rain) may be expected; and the harder, more "greasy," rolled, tufted, or ragged, the stronger the coming wind will prove. Also, a bright yellow sky at sunset presages wind; a pale yellow, wet;—and thus, by the prevalence of red, yellow, or grey tints, the coming weather may be foretold very nearly; indeed, if aided by instruments, almost exactly.

Small inky-looking clouds foretell rain; light scud-clouds driving across heavy masses show wind and rain; but, if alone, may indicate wind only.

High upper clouds crossing the sun, moon, or stars, in a direction different from that of the lower clouds, or the wind then felt below, foretell a change of wind.†

After fine clear weather, the first signs in the sky of a coming change are usually light streaks, curls, wisps, or mottled patches of white distant clouds, which increase, and are followed by an overcasting of murky vapor that grows into cloudiness. This appearance, more or less oily, or watery, as wind or rain will prevail, is an infallible sign.

Usually the higher and more distant such clouds seem to be, the more gradual, but general, the coming change of weather will prove.

Light, delicate, quiet tints or colors, with soft, undefined forms of clouds, indicate and accompany fine weather; but gaudy or unusual hues, with hard, definitely outlined clouds, foretell rain, and probably strong wind.

Misty clouds forming, or hanging on heights, show wind and rain coming—if they remain, increase, or descend. If they rise or disperse, the weather will improve or become fine.

When sea birds fly out early, and far to seaward, moderate wind and fair weather may be expected; when they hang about the land, or over it, sometimes flying inland, expect a strong wind with stormy

* A "high dawn" is when the first indications of daylight are seen above a bank of clouds. A "low dawn" is when the day breaks on or near the horizon, the first streaks of light being very low down.

† In the tropics, or regions of trade winds, there is generally an upper and counter current of air, with very light clouds, which is not an indication of any approaching change. In middle latitudes such upper currents are not so frequent (or evident?) except before a change of weather.

weather. As many creatures besides birds are affected by the approach of rain or wind, such indications should not be slighted by an observer who wishes to foresee weather.

There are other signs of a coming change in the weather known less generally than may be desirable, and therefore worth notice; such as when birds of long flight, rooks, swallows, or others, hang about home, and fly up and down or low—rain or wind may be expected. Also, when animals seek sheltered places, instead of spreading over their usual range; when pigs carry straw to their sties; when smoke from chimneys does not ascend readily (or straight upwards during calm), an unfavorable change is probable.

Dew is an indication of fine weather; so is fog. Neither of these two formations occurs under an overcast sky, or when there is much wind. One sees fog occasionally rolled away, as it were, by wind—but seldom or never formed while it is blowing.

Remarkable clearness of atmosphere near the horizon, distant objects, such as hills, unusually visible, or raised (by refraction),* and what is called "a good hearing day," may be mentioned among the signs of wet, if not wind, to be expected.

More than usual twinkling of the stars, indistinctness or apparent multiplication of the moon's horns, haloes, "wind dogs"† and the rainbow, are more or less significant of increasing wind, if not approaching rain, with or without wind.

Near land, in sheltered harbors, in valleys, or over low ground, there is usually a marked diminution of wind, during part of the night, and a dispersion of clouds. At such times an eye on an overlooking height may see an extended body of vapor below (rendered visible by the cooling of night) which seems to check the wind.

Lastly, the dryness or dampness of the air, and its temperature (for the season), should always be considered, with other indications of change, or continuance of wind and weather.

* Much refraction is a sign of easterly wind.

† Fragments or pieces (as it were) of rainbows (sometimes called "wind-galls") seen on detached clouds.

Enameling Iron.

From the London Chemical News, No. 118.

Enameling iron is almost a new art. No metal is capable of receiving a coating of vitrified porcelain or enamel unless it is capable of withstanding a red heat in a furnace. Articles of cast iron, as a preparation for enameling, are first heated to a low red heat in a furnace, with sand placed between them, and they are kept at this temperature for half an hour, after which they must be allowed to cool very slowly, so as to anneal them. They are then subjected to a scouring operation with sand in warm dilute sulphuric or muriatic acid, then washed and dried, when they are ready for the first coat of enamel. This is made with six parts, by weight, of flint glass broken in small pieces, three parts of borax, one of red lead, and one of the oxide of tin. These substances are first reduced to powder in a mortar, then

subjected to a deep red heat for four hours in a crucible placed in a furnace, during which period they are frequently stirred, to mix them thoroughly; then toward the end of the heating operation the temperature is raised, so as to fuse them partially, when they are removed in a pasty condition and plunged into cold water. The sudden cooling renders the mixture very brittle and easily reduced to powder, in which condition it is called frit. One part of this frit, by weight, is mixed with two parts of calcined bone dust, and ground together with water until it becomes so comminuted that no grit will be sensible to the touch when rubbed between the thumb and the finger. It is then strained through a fine cloth, and should be about the consistency of cream. A suitable quantity of this semi-liquid is then poured with a spoon over the iron article, which should be warmed to be enameled, or if there is a sufficient quantity the iron may be dipped into it and slightly stirred, to remove all air bubbles and permit the composition to adhere smoothly to the entire surface. The iron article thus treated is then allowed to stand until its coating is so dry that it will not drip off, when it is placed in a suitable oven, to be heated to 180 deg. Fah., where it is kept until all the moisture is driven off. This is the first coat; it must be carefully put on, and no bare spots must be left on it. When perfectly dry the articles so coated are placed on a tray separate from one another, and when the muffle in the furnace is raised to a red heat they are placed within it and subjected to a vitrifying temperature. The furnace used is similar to that used for baking porcelain. This furnace is open for inspection, and when the enamel coat is partially fused the articles are withdrawn and laid down upon a flat iron plate to cool, and thus they have obtained their first coat of dull white enamel, called biscuit. When perfectly cool they are wetted with clean soft water, and a second coat applied like the first, but the composition is different, as it consists of thirty-two parts by weight of calcined bone, sixteen parts of china clay, and fourteen parts of feldspar. These are ground together, then made into a paste, with eight parts of carbonate of potash dissolved in water, and the whole fired together for three hours in a reverberating furnace; after which the compound thus obtained is reduced to frit, and mixed with sixteen parts flint glass, five and a half of calcined bone, and three of calcined flint, and all ground to a creamy consistency, with water, like the preparation for the first coat. The articles are treated and fired again, as has been described in the preparation coat, and after they come out of the furnace they resemble white earthenware. Having been twice coated, they now receive another coat and firing, to make them resemble porcelain. The composition for this purpose consists of four parts by weight of feldspar, four of clear sand, four of carbonate of potash, six of borax, and one each of oxide of tin, nitre, arsenic, and fine chalk. These are roasted and fritted as before described, and then sixteen parts of it are mixed with the second enamel composition described, excepting the sixteen parts of flint glass, which is left out. The application and firing are performed as in the other two operations, but the heat of vitrification is elevated so as to fuse the third

and second coats into one, which leaves a glazed surface, forming a beautiful white enamel. A fourth coat, similar to the third, may be put on if the enamel is not sufficiently thick. The articles may be ornamented like china ware, by painting colored enamels on the last of the coats, and fusing them on in the furnace. A blue is formed by mixing the oxide of cobalt with the last named composition; the oxide of chromium forms a green, the peroxide of manganese makes a violet, a mixture of the protoxide of copper and red oxide of lead a red, the chloride of silver forms a yellow, and equal parts of the oxide of cobalt, manganese, and copper form a black enamel when fused. The oxide of copper for red enamel is prepared by boiling equal weights of sugar and acetate of copper in four parts of water. The precipitate which is formed after two hours moderate boiling is a brilliant red. The addition of calcined borax renders all enamels more fusible.—*Engineer.*

Translated for the Journal of the Franklin Institute.

Improvements in the Refining of Sugars.

MM. Leplay and Cuisinier communicated to the Academy of Sciences of Paris, at their session on the 10th of February, 1862, a new mode of purifying saccharine liquids and syrups, and a new means of reviving the animal charcoal employed in the manufacture of sugar.

"In the ordinary process, a filter filled with the charcoal in grain, lasts from 12 to 24 hours; after this time, all its absorbing properties appear to be destroyed, and it must be revived, the principal operation of which is calcination in closed vessels, at a high temperature. Thus revived, however, it has not recovered its original properties completely, and its absorbing power is reduced one-half or even more."

"It is generally believed that all the absorbing powers of the charcoal are destroyed at once, and that the method of reviving restores them all at the same time. The fundamental idea of our method, on the other hand, consists, first, in our having discovered various absorbing powers, and different functions, in the charcoal in grains, which are exercised independently of each other, and are not simultaneously exhausted; secondly, in the successive reviving of these absorbing powers, in proportion as they are exhausted, by different means appropriate to the matters absorbed; thirdly, in the power of increasing at will the energy of the absorption, and thus rendering the purification of the syrups more complete; fourthly, in the disuse of any temperature above that of boiling water."

"By examining what takes place in the filtration of syrups, we have found, contrary to what is generally supposed, that the exhaustion of the absorbing powers of the charcoal may be divided into three periods, which we will examine successively."

"The first series of absorbing powers is nearly exhausted, under ordinary circumstances, in about four hours. These are the powers of absorption of viscous, azotized ammoniacal, sapid and odorous substances, which injure the fluidity of the syrups, their crystallization,

the firmness of grain, and the quantity and quality of the sugar, and which give to the crude sugar their peculiar odor and taste. We re-establish these absorbing powers completely, by passing a current of steam through the charcoal in the filter, and this may be done an indefinite number of times."

"The second series of absorbing powers of the charcoal requires a much longer time for their exhaustion, lasting six or eight times longer than the first. This exhaustion varies with the alkalinity of the defecated syrups. They are the absorbing powers for the free alkalies, potassa, soda, lime, and for salts. These matters especially contribute to the color of the syrups during the evaporation, and destroy the sugar; and when they exist in too great quantity, they prevent the obtaining of the proper degree of boiling for the crystallization. We revive these absorbing powers by a weak solution of chlorhydric acid poured on the filter, and by washing with water for a sufficient time."

"The third series comprises the absorbing power for coloring matters. They last thirty or forty times as long. Besides, the presence of these matters is not of so much importance when the syrups are transparent and brilliant, and contain no material in suspension. With colored syrups, white sugar may be obtained. When we judge it necessary to revive the absorptions, we do so by a weak boiling solution of caustic alkalies."

"All these operations are performed either on the filters themselves, or in apparatus similar to them."

"These different modes of revivification restore the absorbing power of the animal charcoal entirely, but without increasing it. We then sought, in the production of a new substance, fixed in the charcoal itself, the solution of the problem of the increase of the absorbing powers of the charcoal. When we put in a test-glass an equivalent of bi-phosphate of lime, and an equivalent of the tribasic phosphate, identical with that which enters into the composition of animal charcoal, the two combine to form a third, which is a phosphate with two equivalents of base, as is explained by the following formula:—

$$PO_5\ 3CaO + PO_5\ CaO\ 2HO = 2(PO_5\ 2CaO\ HO).$$

"This phosphate is insoluble in water, without acid action on litmus-paper, produces no inversion in sugar, and possesses most powerful absorbing powers. That which is produced in the test-glass, may be done in the same way in a filter containing animal charcoal in grain, by pouring into it a dilute solution of bi-phosphate of lime. The same effect is produced on the charcoal in powder. Animal charcoal thus treated possesses much greater absorbing powers, which can be modified at will, and produce a much more complete purification in the syrups."

"We have also utilized, in the clarification and purification of saccharine liquids, the singular property which the phosphate with three equivalents of lime possesses, of forming a gelatinous precipitate which entangles in its meshes all the matters which trouble the transparency of the syrups much more completely than albumen, blood, or other materials used for clarification."

"The above methods are now in use in two important sugar establishments, and the quantity of sugar made by them up to this time is about 300 tons. They can be applied with equal success in the manufacture and refining of sugar from the cane."—*Cosmos.*

On the Maximum Density of Sea Water. By M. V. Neumann.

From the Lond. Ed. and Dub. Phil. Mag., November, 1861.

Von Neumann, in an inaugural dissertation (Munich, 1861), has published a new determination of the maximum density of sea water. Like Kopp and other physicists, who have made this determination for pure water, he measured the volume at different temperatures in a glass vessel, analogous in construction to a thermometer, the co-efficient of expansion of the glass being carefully determined. This method is well adapted for liquids whose freezing point is above the point of greatest density. The sea water used was obtained from Trieste, Genoa, and Heligoland, and was previously well mixed. Its freezing point was found to be —2·6° C., and its specific gravity at 0° C. 1·0281; its point of greatest density was —4·7364° C.

This number is more than that obtained by Despretz (—3·67°C. for sea water of 1·0273 sp. gr.) and Erman (—3·75° C.), but would probably agree with that of Marcet (—5·25°C.) and Horner (—5·56°C.), if a correction for the expansion of glass were introduced.—Poggendorff's *Annalen*, August, 1861.

Resistance of Square Bars to Torsion. By W. J. Macquorn Rankine.

From the Civ. Eng. and Arch. Jour., March, 1862.

Sir—It is very desirable that the attention of writers on the strength of materials should be called to the theoretical investigations of M. de St. Venant, especially those on torsion, which were published in the "*Mémoires des Savans Etrangers*," vol. xiv., about six years ago, but appear to have been almost wholly overlooked, although some of their results are of much practical importance.

According to the ordinary theory of the torsion of a straight uniform bar, each originally plane section perpendicular to the axis, continues to be plane and perpendicular to the axis when the bar is twisted. It is easy to see that this supposition is rigorously exact for a cylindrical bar only; but it seems to have been generally taken for granted that the errors to which it leads when applied to bars of other forms are unimportant in practice. M. de St. Venant shows that they are of importance; and, by a very skilful and laborious mathematical investigation, he obtains approximate formulæ in which allowance is made for the effect of what he calls the "gauchissement" (which may be translated the *warping*) of the originally plane cross-sections of bars that are not cylindrical. He arrives at the result, that the whole

of the ordinary formulæ relating to torsion are erroneous, except those for cylindrical bars.

The most important case in practice to which the method of M. de St. Venant has been applied, is that of a square bar, wrenched asunder by torsion.

Let h denote the side of the bar; f, the modulus of rupture by wrenching, or greatest intensity of the stress when the bar gives way; then the moment M of the force required to wrench asunder the bar is,

According to the ordinary formula, $M = \cdot 2357 f h^3$;
According to the improved formula, $M = \cdot 281\ f h^3$.

In the reduction of experiments on wrenching equal bars asunder, the following are the values of the modulus f:

According to the ordinary formula, $f = \dfrac{M}{\cdot 2357\, h^3}$;

According to the improved formula, $f = \dfrac{M}{\cdot 281\, h^3}$.

To these may be added the corresponding formula for cylindrical bars, in which alone M. de St. Venant makes no alteration,

$$f = \frac{M}{\cdot 196\, h^3}.$$

An easy test of the accuracy of the formulæ for square bars is to try whether, when applied to experiments, they give values of f agreeing, or nearly agreeing, with those deduced from experiments on round bars. I have lately applied that test to them by the aid of the experiments of Mr. George Rennie and Messrs. Bramah on square bars of cast iron, and Mr. Dunlop on round bars of the same metal, as quoted by Mr. Hodgkinson in his work on Cast Iron (articles 201 to 204 inclusive), with the following results. (See also, as to Mr. Dunlop's experiments, Tredgold on Cast Iron, page 98.

	Modulus of Wrenching, f.	
	Ordinary formula.	M. de St. Venant's formula.
Square Bars.	lbs. on the sq. in.	lbs. on the sq. in.
Mean of Mr. Rennie's experiments, .	32,227	27,070
Mean of Messrs. Bramah's experiments,	37,747	28,640
General mean, . .	34,987	27,855
Cylinders.		
Mean of Mr. Dunlop's experiments, .	27,534	27,534
Difference, . .	7,453	321

It is obvious that the difference between the results of experiments on square and round bars, according to M. de St. Venant's formula,

falls within the limits of the ordinary variations of experiments on the strength of materials; which limits it greatly exceeds when the ordinary formula is applied.

GLASGOW, 4th February, 1862.

A Description of a Steam Hammer for Light Forgings. By Mr. RICHARD PEACOCK, of Manchester.

From Newton's London Journal, Aug., 1861.

Power hammers are almost indispensable for the production of sound smiths forgings, and their extensive introduction into the smithery has been attended with most valuable results. Their application is not of recent date, but the extraordinary demand for forged iron work for steamboat and railway work has given an impetus to their use, and their adaptation to the more general wants of the smith's shop is marked by great advantage as regards both efficiency and expedition.

The steam hammer described in the present paper, is now in use at the author's works, Gorton Foundry, Manchester; and is brought before the meeting by request, as an example of a practical and useful steam hammer for light forgings, heavy smith's work, stamping, &c. This hammer is worked by hand, and is either single or double acting; that is, it can either be lifted by steam and allowed to fall by gravity alone, or, after it has been lifted, steam can be used above the piston to give increased effect to the blow.

The steam cylinder is 10 inches diameter, and constructed for a 24 inch stroke. The valve is cylindrical, turned to fit well in the valve chest, but to move easily within it. The top end of the valve is made longer on one side than on the other, and, in one position, therefore, of the valve, steam is admitted above the piston in the down stroke, but by turning the valve half round, by means of a handle, the additional lap is brought into use, which prevents the admission of steam above the piston, and allows the hammer to fall by gravity alone. The valve is worked up and down by a hand lever; it is open through the centre, and the weight of the valve, valve rod, and hand lever, is counterbalanced by a spiral spring. To prevent the piston from rising too high in the cylinder, a trigger is fixed on the side frame, which when struck by a roller on the hammer block, lowers the valve, and allows the steam to escape from beneath the piston.

The piston is secured to the rod in the usual way by a cone and nut. The bottom end of the rod has a solid head, by which it is secured to the hammer block. This head is rounded on the top and bottom, and is made $\frac{1}{4}$ inch less in diameter than the hole in the hammer block, to allow of any twist or vibration, and prevent the breaking of the piston rod, which, from the oblique strain due to the varied character of the forgings, has hitherto given great trouble in steam hammers. The weight of the piston, piston rod, and hammer block, is $12\frac{1}{2}$ cwts., or 1400 lbs.

From diagrams which the author exhibited, the mean pressure of steam in lifting the hammer was shown to be 25·7 lbs. per square inch,

which, multiplied by 66 square inches area of the lower side of the piston, is equal to 1696 lbs. total; and the mean back pressure against the hammer when falling, including cushioning, was 4·3 lbs. per square inch, or 284 lbs. total. A partial vacuum was formed above the piston in falling, equal to 1·6 lbs. per square inch, or 126 lbs. total on 78·5 square inches area of the top of the piston; this added to the back pressure below the piston, gives a total retarding pressure of 410 lbs. to be deducted from the weight of the hammer. Thus the effective weight of the hammer is 1400 lbs. less 410 lbs., or 990 lbs.; say 9 cwts., or 29 per cent. less than the real weight of the falling mass. This weight multiplied by the height of the fall, 20 inches, gives an effective blow of 1650 lbs., or 14¾ cwts. falling one foot: friction not being taken into account.

Diagrams taken below the piston when steam was used above, the hammer working with the same stroke of 20 inches at 112 blows per minute, showed the mean pressure in lifting the hammer to be equal to 30·1 lbs. per square inch, or 1987 lbs. total; and the mean back pressure when the hammer was falling, 5·4 lbs. per square inch, or 356 lbs. total. Diagrams taken above the piston when steam was used above, the hammer working as before, with a stroke of 20 inches at 112 blows per minute, gave the mean pressure of steam during the down stroke 32·1 lbs. per square inch, or 2520 lbs. total; and the mean back pressure above the piston when rising, 8·8 lbs. per square inch, or 691 lbs. total. Hence the effective pressure of the steam on the top of the piston, was 2520 lbs. less a back pressure of 356 lbs., or 2164 lbs.; which, added to the weight of the hammer, gave a total effective weight of 3564 lbs., or 31¾ cwts. This weight multiplied by the height of the fall, gives an effective blow of 5940 lbs., or 53 cwts. falling one foot, when the steam is admitted above the piston; which compared with the blow of 14¾ cwts. when the hammer falls by its weight alone, shows an advantage of 3½ to 1.

Diagrams taken below the piston with the hammer making a stroke of 10 inches and 117 blows per minute, and falling by gravity alone, gave an effective action calculated as in the preceding case, equal to 709 lbs., or 6¼ cwts. falling one foot. When steam was used above the piston, the hammer working with the same stroke of 10 inches at 150 blows per minute, the effect given by the diagrams was equal to 2396 lbs., or 21½ cwts. falling one foot; showing a superiority of 3¼ to 1 over the hammer falling by gravity alone.

Diagrams taken below the piston, the hammer working with a stroke of 5 inches, at 147 blows per minute, and falling by gravity alone, gave an effect equal to 380 lbs., or 3½ cwts. falling one foot. Others taken below and above the piston when steam was used above, the hammer working with the same stroke of 5 inches at 180 blows per minute, gave a result equal to 1149 lbs., or 10¼ cwts. falling one foot; showing an advantage of 3 to 1 over the hammer falling by gravity alone.

The Chairman observed, there appeared to be two points particularly to be noticed in the hammer just described:—the simple mode of

altering the lap of the valve by the use of a cylindrical valve that could be turned round by hand into any position between the two extremes of no lap or full lap; and the ingenious mode of attaching the piston rod to the hammer block for overcoming the difficulty experienced in previous hammers from breakage of the piston rod. He inquired how many of the hammers were now at work, and of what size, and what was the cost of the hammer.

Mr. Peacock replied that there were now three of the hammers at work, all of the size shown in the drawings, one of which had been working about eight months; the cost was about £175, exclusive of the anvil. He showed a full size specimen of the valve, and explained that it was worked by hand with the greatest ease, being made hollow for the steam to pass through, so that it was completely balanced; and having a lap half round the circumference at the top end, it could be turned round by hand, so as entirely to prevent the steam entering above the piston, for giving light finishing blows with the hammer. The chief object in the hammer was simplicity of construction, by the absence of gearing for working the valve; it was therefore not likely to get out of order, while the working was completely controlled by hand; and it was particularly serviceable for smith's work, where no two blows were wanted alike.

Mr. F. J. Bramwell had long been convinced that gravity alone was not sufficient for working steam hammers, because a great part of the effect was lost whenever the height of fall was diminished by having a large mass on the anvil. He had aided in devising a steam hammer some years ago for crushing ore, and also for forging iron; the falling weight was 30 cwts., but by using steam on the top of the piston, the force of blow of a large hammer was got out of a small one, with a rapidity of stroke that could not be attained by gravity alone. The piston rod was made very large, half the area of the piston, so that the steam had only the annular area to lift by; and for the down stroke the steam was exhausted from the bottom of the cylinder into the top, where it acted upon the whole area of the piston, producing a total effective pressure corresponding to half the area. Two of these hammers had been put to work at Rotherham, about six years ago, and continued working there satisfactorily. The principal difficulty he had experienced was in attaching the piston rod to the hammer block, which had been done in the first hammer with two keys driven in horizontally from each side, and with wood packing to produce a certain amount of elasticity; but the keys got loose with the jarring of the blows, and came out. To prevent this, they were then put in obliquely, inclined downwards, which caused them to remain secure; all elastic packing in the hammer block was abandoned, the keys being driven in tight to make a rigid attachment; and this plan succeeded entirely. The connexion of the piston also to the rod was frequently a difficulty, and he thought the best plan was to forge it solid on the rod, and make it steam-tight with Ramsbottom's packing rings, so as to have as light a packing ring as possible. Where a steam hammer was required, he doubted whether it was ever desirable

to work it without any steam on the top; but the valve now shown would be very useful for altering the degree of lap and varying the admission of steam above the piston. In the indicator diagram, the vacuum shown above the piston in falling when the hammer worked single-acting, seemed much less than he would have expected if there were no air drawn in except through leakages.

Mr. C. W. Siemens said, it seemed extraordinary there should be so small a vacuum above the piston, when no air or steam was admitted; but this might be explained by the circumstance that the surfaces of the cylinder remained wet from the preceding up stroke, and a generation of steam would take place from them as soon as the pressure fell below that of the atmosphere.

Mr. C. Markham inquired how the length of stroke of the hammer was varied. There was a great advantage in being able to use steam above the piston when required, but he did not think it was desirable to do so always, as there would then be a loss in working with a short range, because a whole cylinder full of steam would be thrown away at each stroke.

Mr. Peacock replied that the length of stroke was varied entirely by the hand lever, which could be done to a great nicety after a little practice.

Mr. E. A. Cowper observed that the loss of steam in working the hammer at a short range with steam above the piston would be greatly reduced by the plan mentioned by Mr. Bramwell, of enlarging the piston rod and using the same steam above the piston that had previously lifted the hammer; the additional work got out of the steam in the down stroke was then all gained. The indicator diagram, taken from the top of the cylinder when the hammer was working single-acting, showed the want of a steam jacket, by the fact of the pressure produced by generation of steam from the wet surface of the cylinder; and he believed all steam hammers required jackets quite as much as the cylinders of steam engines; for if there were any moisture on the surfaces of the cylinder, it showed that a quantity of steam was passing through without doing duty, being merely condensed in the cylinder and then evaporated again. He inquired why the back pressure below the piston was so high in all the diagrams, and suggested that it might be greatly diminished by making the middle of the valve half a port longer than the distance between the ports, so as to obtain a much more free exhaust: this plan he had carried out extensively in steam engines, with excellent effect.

Mr. Peacock replied that the greater part of the back pressure was due to the cushioning in the last portion of the stroke, as shown by the diagrams, and there was only a small back pressure in the previous portion of the stroke. Cushioning was necessary for lifting the hammer again more readily after the blow, and to insure lifting it clear without repetition of the blow. The addition of a steam jacket round the hammer cylinder would no doubt be desirable where economy of steam was of importance, though of course increasing the first cost to some extent; but, at his own works, the steam was not

considered an important item, as it was supplied from vertical boilers heated by the furnaces, and there was still steam blowing off while the hammer was at work.

He explained the mode of attaching the piston rod to the hammer block so as to make a good and durable connexion; the hammer block being made of wrought iron, with a bore hole carried right through, in order to get the boring bar in for boring the upper portion of the block. A hard wood packing of oak, teak, or ash, was inserted in the bottom of the block between two wrought iron washers, against which the bottom of the piston rod bore with a cheese head, $\frac{1}{4}$ inch smaller in diameter than the hole in the block; above the cheese head was another washer, and then two cotters, one on each side of the rod, which avoided weakening the rod by cutting cotter holes through it. The hammer was then put to work, and the cotters gradually tightened up; and after a week's work, new cotters were put in, slightly larger, so as to fit tight, which would then last for three or four months without any attention.

Mr. R. Williams inquired what sort of gland was used at the bottom of the cylinder, and what packing was employed for the piston.

Mr. Peacock replied that it was simply an ordinary stuffing-box at the bottom of the cylinder; the piston was made with two of Ramsbottom's packing rings, which would remain steam-tight for eighteen months or more without taking out, and he had had a Nasmyth hammer working with them for four years. He was now making a 4-ton hammer on this construction, in which the exhaust side of the valve would be made longer than the distance between the ports, in order to prevent a vacuum being formed above the piston in falling, when working single-acting, by allowing some of the exhaust steam from below the piston to pass into the top of the cylinder.

Mr. W. Naylor doubted whether the same accurate adjustment of the blow could be got in working the valve by hand as when gearing was used; in a rapid play of blows he thought the hammer would only just touch the anvil, without giving much force of blow, and the valve would have to be reversed some time before the piston reached the top of the cylinder, to prevent any chance of keeping the steam on too long. He had found the great desirability in a forge of having a hammer that could be worked single-acting or double-acting as required; for when the iron was brought under the hammer at a welding heat, it wanted quick light blows at first for welding it together, and then heavy blows for working it into shape, which could be done with a double-acting hammer at the same heat; and the fewer heats the work had to go through, the better and quicker it was done. He thought the valve described appeared similar to that in his own hammer, which had been described at a former meeting. He asked whether any breakage of the cotters in the hammer block had occurred since first starting.

Mr. Peacock replied that they had never had any cotters broken during eight months work, and the attachment of the piston rod and

hammer block continued perfectly fast. The valve was designed as a simple form of balanced valve, that could be cast all in one piece, and required only turning up on the outside without any fitting. For ordinary smiths work, the hammer was oftener wanted without the steam on the top than with it; but in forging work under dies, very heavy blows were required, and it was a great advantage then to have the means of increasing the force of blow with the same hammer. By dispensing with gearing for working the valve, the construction was much simplified, and the hammers were found to be handier for the men than a Nasymth 15 cwt. hammer worked by gearing in the same shop: the boys who worked the valves got quite perfect in managing them after three or four days practice, and gave exactly the force of blow that the smith directed.

Proc. Mech. Eng. Soc.

Oblique-Jointed Steam Boilers.

From the Lond. Mining Journal, No. 1306.

The absolute necessity of the highest attainable strength being secured for steam boilers is universally admitted; and that there was much room for improvement was proved by the experiments of Mr. William Fairbairn, having discovered that in cylindrical vessels subjected to internal pressure the strength in their longitudinal direction is twice that of the plates in their curvilinear direction, and that an ordinary riveted joint, of good proportions and workmanship, has but half the strength of the solid plate. Taking these facts into consideration, it is evident that (since the joints are but one-half the strength of the solid plate, and the transverse strength is considerably less than the longitudinal) it is of paramount importance to remove the necessity for longitudinal joints, for by that means the strength may be very materially increased without adding to the weight of the boiler. By an ingenious arrangement patented by Messrs. Wright and Co., of Goscote Works, Walsall, a stronger boiler is produced than has hitherto been practicable. The crossing of the joints has been much relied on, and doubtless it is highly beneficial; but in addition to this Messrs. Wright further increase the strength by arranging all the joints diagonally. In the patent boiler longitudinal joints are entirely dispensed with, and a system of equal oblique or diagonal joints adopted throughout. Its weaker section is altogether avoided by the lines of riveting; and the transverse or double strain, which in the common boiler acts only upon two opposite ends of the plates, in the patent boiler is distributed equally around them. By this diagonal arrangement of the joints, all the riveting of the boiler assists equally in supporting the transverse strain, instead of the longitudinal joints alone being left to contend with it, as in the common plan; and this is accomplished without any increase in the whole amount of riveting, except only when it may be required to give a surplus of strength to the joints, in which case less than 5 per cent. of additional riveting will suffice. And the patent boiler thus

made is preferable to any that might be made with welded joints, because more reliable; for the risk of imperfect welding would be greater than that of imperfect riveting. All the boilers constructed upon this principle are made to bear a pressure from six to nine times that at which it is to be worked, and every boiler is tested up to double the working pressure before it leaves the establishment.

Metallic Alloy.

From the Lond. Mining Journal, No. 1309.

Mr. Johann Aich, Venice, has patented some improvements in amalgamating metals, which consist in forming an alloy of—copper, 60℔s.; zinc, 38 ℔s. 2 ozs.; and iron, 1 ℔. 8 ozs. The zinc may be increased to 44 ℔s., and the iron diminished to ½ ℔. or increased 3 ℔s. If the amalgamation of the parts be perfect, the product may be worked both hot and cold. At a red heat it is malleable like the best wrought iron, and may be beaten, stamped, or drawn. It is cheaper than brass, and may be advantageously substituted for brass and copper, and resists the action of sea water satisfactorily.

A New Fuel for the Navy.

From the London Mining Journal, No. 1355.

The great advantages of using large coal of high evaporative power for steam purposes generally, and more especially for marine purposes, is universally admitted; and it will consequently be gratifying to the shipping interest to learn that the Crown Preserved Coal Company's first year's operations have been of the most successful character. The blocks of fuel manufactured by this company are of the uniform size of 1 cubic foot, and of the uniform weight of 56 ℔s.; whilst the space required for stowage is materially less.

To show the practical advantages of using preserved coal, the company quote an instance of a steam voyage to Rio Janeiro:—

"The quantity of coals to be taken from Southampton would be 1000 tons, at a cost of about £900, and occupying 1050 tons of space. On the other hand, 1000 tons of preserved coal would cost £100 more, but there would be a saving of 250 tons of space, which, at the usual rate of £6 per ton of freight, would produce £1500. This amount would not only pay for the preserved coal, but leave a surplus of £500 extra profit, merely for the outward voyage."

Amongst the other advantages claimed for the artificial fuel, as compared with ordinary coal, are the circumstances that by the process employed the fuel is made so dry that decomposition is arrested; that it is free from dust, and nearly as clean as blocks of stone; that it is not liable to spontaneous combustion, neither does it emit gas or smell of any kind, nor involve risk or injury of cargo, and that the evaporating power of the fuel is nearly 10 per cent. greater than any

other description of coal known. The fuel has been favorably reported upon by Commander Watson, of Her Majesty's ship *Royal Albert*, and has been extensively used by several of the large steam navigation companies.

On the Deficiency of Rain in an elevated Rain-Gauge, as caused by Wind. By W. S. Jevons, B. A., of University College, London.

From the Lond. Edin. and Dub. Phil. Mag., December, 1861.

My conclusions, shortly stated, are:—

1. An increase of the rainfall close to the earth's surface is incompatible with physical facts and laws.

2. The individual observations on this subject are utterly discordant and devoid of law when separately examined, and the process of taking an average under such circumstances gives an apparent uniformity which is entirely fallacious.

3. When daily measurements of rain, or even monthly totals, are examined with reference to the strength of the wind at the time, it becomes obvious that there is a connexion.

4. Wind must move with increased velocity in passing over an obstacle. It follows demonstratively that rain-drops falling through such wind upon the windward part of the obstacle will be further apart, in horizontal distance, than where the wind is undisturbed and of ordinary velocity.

London, August 28, 1861.

For the Journal of the Franklin Institute.

Armor-Clad Ships of War. By Wm. H. Shock, Ch. Eng. U. S. N.

The late naval engagement between the *Monitor* and *Merrimac* in Hampton Roads, inaugurated a new and highly important change in naval warfare—a change destined to set aside our preconceived notions of what was supposed to be the perfection of war ships; indeed, so marked and immediate have been the modifications, if not the entire change of opinion on this subject at the Navy Department, that already workmen are busy in cutting down and in other respects preparing one of our first class steam frigates (the *Roanoke*) for the reception of an armor.

The idea of introducing iron ships for naval purposes originated in this country with the late R. L. Stevens, of New York, one of the most distinguished scientific gentlemen of his day, and by him suggested to the Government in 1841. It was not until 1854, however, that work on the present battery was commenced, and in twenty months it assumed its present advanced condition, since which time nothing has been done towards its completion; and it was reserved for the *Monitor* and her officers to be the first successfully to demonstrate, by a practical test of five hours desperate fighting (with an enemy worthy of her), that the day of wooden ships for war purposes had passed, and

henceforth *Monitors* and "*Enemy repulsed*" were to be synonymous terms.

England and France have not been slow to estimate the superiority of iron ships for war purposes; but with them, as with ourselves, there is a diversity of opinion as to the best plans, and as this question will have to be decided by experience and experiments, the inventive genius of the present age will have an ample field in that direction.

The English Government in 1855-6 built three armor-clad ships of war, the *Thunderbolt*, *Etna*, and *Terror*, from designs and under the direction of the Admiralty; they were intended especially for an attack on Cronstadt, but the war with Russia terminated before they were brought into active service. These appear to have been the first iron ships of war constructed by the English Government, and that they possessed in the principles of their construction many elements of success, I think will be proven by future experience.

A description of these ships, given before the Institution of Naval Architects by Mr. Samuda, on the 28th of February, 1861, will be found interesting:—

"They were 2000 tons burthen, and pierced for 30 guns; drew when ready for sea 8 feet 6 inches. The hulls were built *entirely of iron;* the top sides were then covered with teak 6 inches thick, and reached from the gunwale to about 2 feet below the deep water line, a distance of about 13 feet, and this teak was again covered with wrought iron armor plate averaging 4 inches in thickness, bolted against the teak and through it and the iron skin of the vessel. The armor reached from stem to stern, and thus protected the entire topside of the ship, and also two feet under the water."

The construction of the *Warrior* and *Black Prince* seems to have been the next decided step in the introduction of iron-clad ships of war in England, and exceeded in gigantic proportions in tonnage and general dimensions the *Thunderbolt* and her compeers, as will be seen from the following dimensions of the two ships, viz:—

Length,	380 feet.
Beam,	58 "
Depth of hold,	33 "
Tonnage,	6038 tons.

They were protected by 4½ inch armor plates for about 200 feet of their midship length, extending from gunwale to 5 feet below the water line, with 18 ins. of teak backing interposed between the armor plates and the skin of the ship, but the ends of the vessels were left unprotected. In this particular the *Warrior* and *Black Prince*, as well as the Philadelphia iron-clad vessel, are alike defective. The wonderful degree of accuracy obtained in heavy ordnance practice, renders it imperative that no vulnerable points be exposed.

The *Monitor*, *Galena*, and a third iron-clad vessel that I shall term the *Philadelphia Iron-clad*, were contracted for at the same time, all differing from each other in every particular. To the latter I propose to devote the remainder of this paper.

The *Philadelphia Iron-clad* is being built by and from designs of Messrs. Merrick & Sons, Southwark Foundry, Philadelphia.

The following are her dimensions:

HULL (wood).

Length,	232 feet.
" between perpendiculars,	230 "
Beam,	57 " 6 ins.
Depth of hold,	17 "
Tonnage by measurement,	3436 tons.
Draft of water at deep load line,	15 feet.
Displacement,	4120 tons.
Immersed sectional area,	809 sq. ft.
Immersed section per square foot of screw's disk,	6·09
Angle of entrance at load line,	92°
" departure,	166°
Area of immerged portion of hull,	16,325 sq. ft.
Weight of hull, *per se*,	2000 tons.
Estimated weight of armor,	750 "

Barque rigged.

BATTERY.

16 9-inch Dahlgren guns, eight on a side.

Weight of guns,	152,000 lbs.
" metal thrown at one broadside (shell),	592 "
" " " " " (shot),	800 "

ENGINES.

She is supplied with two horizontal, direct-acting engines.

Diameter of cylinders,	50 inches.
Stroke of piston,	30 "
Surface condensers—Condensing surface,	3000·3 sq. ft.
Diameter of air pumps,	$12\frac{1}{2}$ "
Stroke of "	30 "
Diameter of circulating pumps,	11 "
Stroke of "	30 "
Lap on steam valve, steam side,	$1\frac{1}{2}$ inches.
" " exhaust side,	$\frac{3}{4}$ "

BOILERS.

She is furnished with four horizontal tubular boilers.

Heating surface to top of tube box,	8450 sq. ft.
Grate surface,	355 44 "
Ratio of grate to heating surface,	1 to 23·7.
Estimated consumption of coal per sq. ft. of grate per hour,	12·6 lbs.
" water evaporation per lb. of coal,	8·5.
" consumption of coal per 24 hours,	$48\frac{840}{2240}$.

Artificial draft.

PROPELLER.

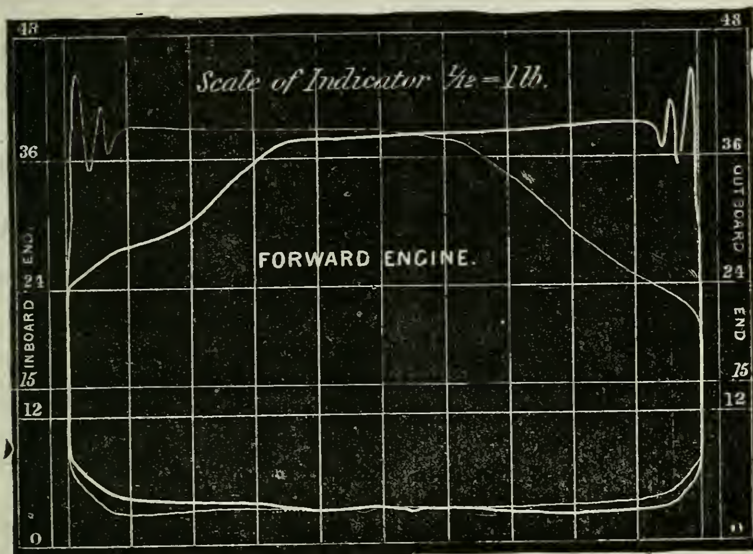
One composition screw.

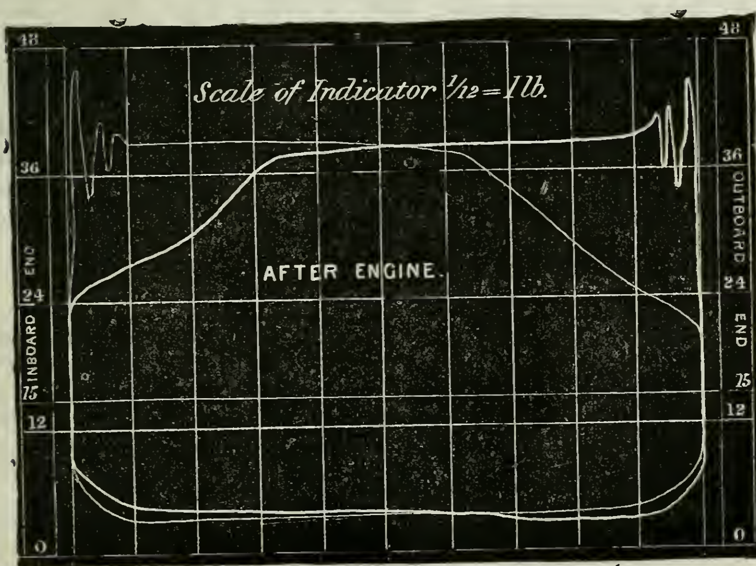
Number of blades,	4.
Diameter,	13 feet.
Pitch, 15 to 17 feet—mean,	16 "
Length,	29 inches.

Theoretical Disposition of Power of Engines and Speed of Ship under favorable circumstances.—Having the data necessary, the following engine diagrams are constructed, from which the estimated engine performance is deduced:

Pressure per gauge,	28 lbs.	Revolutions, ...	80.
Vcauum " . . .	26 "	Hotwell, ...	110°.

Consumption of coal per hour, 4500 lbs.





The above diagrams show a mean effective pressure of 30·88 lbs. per square inch acting on the pistons, and using these figures with

the other data as shown by the diagrams, we have as the total developed power of the engines,

$$\frac{1963 \cdot 5 \times 30 \cdot 88 \times 400 \times 2}{33000} = 1470 \text{ H. P.}$$

From this H. P., however, the usual deductions are to be made before determining the actual engine power utilized in propelling the ship.

The power absorbed in overcoming cohesive resistance of water to the screw's passage through it, will be the first considered, and in doing which the following table is constructed:—

Engine Power Absorbed in Overcoming Resistance of Water to Screw's Passage through it.

Pitch, $15 + 17 \div 2 = 16$ mean. Mean length, 2 ft. 5 ins. Fraction of pitch used, ·151. Revolutions per minute, 80.

No.	Pitch of element.	Radii of element in feet.	Cir normal to radii of element.	Length of element for one convolution of thread.	Length of element used.	Breadth of element.	Area of element.	Speed of element in feet per second.	Speed of element in feet per second.	Friction in pounds.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
1	16	1 0989	6·90	17·46	2·627	·8	2·101	23·2	1392·0	7,671·36
2	"	1·75	10·99	19·38	2·926	·5	1·463	25·64	1550·4	6,677·57
3	"	2·25	14·13	21·34	3·222	·5	1·611	28·45	1707·2	10,011·02
4	"	2 75	17·27	23·54	3·554	·5	1·777	31·38	1883·2	14,824·73
5	"	3·25	20·42	25·94	3·916	·5	1·958	34·68	2075·2	21,976·36
6	"	3·75	23·56	28·48	4·300	·5	2·150	37·64	2278·4	31,191·29
7	"	4 25	26·70	31·12	4·699	·5	2·349	41·36	2489·6	44,787·80
8	"	4·75	29 84	33·85	5·111	·5	2 555	45·13	2768·0	66,367·20
9	"	5 25	32·98	36·65	5 534	·5	2·767	48·85	2932 0	87,048·14
10	"	5·75	36·12	39 50	5·964	·5	2·982	52·66	3160·0	117,552·00
11	"	6 25	39·27	42·21	6·403	·5	3·201	56·28	3376·8	154,215·84
							24·914			561,723·31

From the above table it will be observed that the total area of elements for one side of one blade is 24·914, and $24 \cdot 914 \times 4 = 99 \cdot 65$ sq. feet, the total area of all the elements used. It will also be observed from column 10, that the surface resistance in pounds for one side of one blade is 561723·31, and

$$\frac{561723 \cdot 31 \times 2 \times 4}{33000} = 136 \cdot 175 \text{ H. P.}$$

From which a deduction is to be made for the rounding of the corners of the blades equal to an area of 6 sq. ft., and having a velocity due to the outer element as follows:

$$\frac{42 \cdot 21 \times 80}{60} = 56 \cdot 28,$$

the speed per second of the outer elements;

and $\quad 10^2 : 56 \cdot 28^2 :: \cdot 45 : 14 \cdot 253, =$ the lbs. per sq. ft.,

and $$\frac{14 \cdot 253 \times 6 \times 3376 \cdot 8}{33000} = 8 \cdot 75 \text{ H. P.}$$

and $\quad 136 \cdot 175 - 8 \cdot 75 = 127 \cdot 32$ H. P.

the total labor of the engine absorbed in overcoming the cohesive resistance of the water to the screw's passage through it.

The following is a general synopsis of the other deductions or theoretical disposition of the power of the engines:

Total horse power developed,	1470·00	or	100	per cent.
Horse power to work engines (*per se*)	95·10	"	6·47	"
	1374·9			
Horse power transmitted to screw shaft,	1374·9	or	100	per cent.
" required to overcome friction of load,	103·11	or	7·5	"
" " " cohesive resistance of water to screw's passage through it,	127·425	"	9·26	"
" expended in slip of screw,	412·47	"	30	"
" utilized in propelling ship,	731·9	"	53·24	"
	1374·9	"	100	"

Estimated Speed of Ship under favorable circumstances.—Allowing 80 revolutions of screw per minute, with a mean pitch of 16 feet and 30 per cent. slip, we have for the speed of the ship as follows:

$$\frac{80 \times 60 \times 16 \times \cdot 70}{6080} = 8{\cdot}84 \text{ knots per hour.}$$

On the Effect of the Presence of Metals and Metalloids upon the Electric Conducting Power of Pure Copper. By A. MATTHIESSEN, PH. D., and M. HOLZMANN, PH. D. Communicated by Professor WHEATSTONE, F. R. S.

From the Lond. Artizan, Nov., 1860.

As the electric conducting power of copper varies so much according to different experimenters, we thought it would be of some interest to study the causes of these differences; and on comparing the values found for copper, we find that, taking silver = 100, copper conducts according to

Becquerel,*	95 3	Harris,§	100·0
Riess,†	67·2	Buff.‖	95·4
Lenz.‡	73·4	Pouillet,¶	73·0
Davy,§	91·2	Arndtsen,**	98·7
Christie,§	66·0		

The temperatures at which the above observations were made are only given in the cases of Becquerel, Lenz, and Arndtsen, who compared copper at 0° C. with silver at 0° C. = 100.

We prepared therefore pure copper,—

1. By precipitating with sulphuretted hydrogen the purest commercial sulphate of copper dissolved in water acidulated with sulphuric acid, dissolving the washed sulphide in nitric acid, precipitating at a

* Ann. de Chim. et de Phys., Ser. 3, vol. xvii., p. 242.
† Poggendorff's Annalen, vol. xlv., p. 20.
§ Gmelin, vol. i., p. 289.
¶ Muller, Lehrbuch, der Physik, p. 202.
‡ Ibid, p. 105.
‖ Buff, Grundriss, der Physik, 348.
** Poggendorff's Annalen, vol. cv., p. 1.

boiling temperature by carbonate of soda in excess, and finally reducing the oxide of copper with pure hydrogen.

2. By precipitating sulphate of copper galvanoplastically by a very weak current.

We have also tested the galvanoplastic copper of commerce, and have found that its conducting power is the same as that of the copper we prepared.

The method used for the determinations was the same as that described in the *Philosophical Magazine* (February, 1857). The diameters of the wires used were about 0·25 to 0·5 millim., and the lengths from 0·5 to 1·5 metre; and of each specimen of copper or alloy two or three determinations were made with wires of different diameters.

The following are the results obtained with pure copper, compared with a hard drawn silver wire = 100 at 0° C. (all the wires were hard drawn):—

		Means.
I. Copper purified by the above method (1),	*a.* 92·63 at 18·0 *b.* 93·36 at 19·2	93·00 at 18·6°.
II. Copper, galvanoplastic, not fused,	*a.* 93·81 at 19·7 *b.* 93·56 at 20·5 *c.* 93·00 at 20·4	93·46 at 20·2.
III. Copper, galvanoplastic commercial, not fused,	*a.* 92·24 at 18·0 *b.* 93·01 at 18·5 *c.* 93·81 at 18·7	93·02 at 18·4.
IV. Copper, No. 3, fused in a porcelain tube in hydrogen,	*a.* 92·22 at 19·3 *b.* 93·30 at 19·3	92·76 at 19·3.
V. Copper, No. 3, fused, as will be presently described,	*a.* 92·57 at 17·8 *b.* 93·40 at 17·2	92·99 at 17·5.

The mean of the above twelve determinations gives 93·08 at 18·9° for the conducting power of pure copper.

Peltier* and others have already observed that annealed copper wire conducts better than hard drawn wire; and on repeating the experiments with hard drawn wires from copper No. 2, and which were annealed in a current of pure hydrogen, we found the following numbers:—

I. Hard drawn,	95·31 at 11·0°
Annealed,	97·83 at 11·0
II. Hard drawn,	95·72 at 11·0
Annealed,	98·02 at 11·0

which makes a difference in the conducting powers of hard drawn and annealed wires of about 2·5 per cent.; much greater, however, is the difference between hard drawn and annealed silver wires, as the following experiments show:—

I. *a.* Hard drawn,	95·28 at 14·6°
b. Annealed,	103·98 at 14·8
II. *a.* Hard drawn,	95·36 at 14·6
b. Annealed,	103·33 at 14·6

We will now proceed to describe what is the effect of the metal-

* Ann. de Chim. et de Phys., lvi., p. 371.

loids, and afterwards of the metals, on the conducting power of copper.

1. *Effect of Oxygen* (*Suboxide of Copper*).

Copper readily absorbs oxygen from the air when in a fused state; and it is supposed to be present as suboxide, which it retains very obstinately; and in fact we may lead hydrogen over fused copper, in a porcelain tube, for hours without completely reducing the suboxide. It is also very difficult to prevent the oxygen being absorbed during casting, &c. In order to prevent all these sources of error, we thought that in making the alloys of copper by the following method, we might obviate them :—

In the furnace door communicating with a closed muffle are two holes; through the upper one passes a glass tube connected with a carbonic acid gas apparatus, and through the lower one passes a clay tobacco-pipe, to the stem of which is joined the bottle evolving hydrogen. The hydrogen is washed with potash, nitrate of silver, and concentrated sulphuric acid, and the carbonic acid gas with bicarbonate of potash and strong sulphuric acid. The metal (about 8 grms. were taken for each experiment) was placed in the bowl of the pipe, and so fused in a current of hydrogen; when fused, the hydrogen bubbled up through the melted metal; thus by offering a fresh surface to the hydrogen, any suboxide that might be present was reduced, and when making the copper alloys complete mixture was effected. When the hydrogen had passed through for a certain length of time, the india rubber tubing was disconnected from the sulphuric acid bottle, and the fused metal carefully sucked into the pipe-stem, forming a wire which might, if necessary, be drawn finer. The carbonic acid gas was used to help to drive the air out of the muffle, as well as in some experiments which will be presently detailed.

In order to test the method, copper No. 3 was fused in the pipe, and kept so for about half an hour, when we found the conducting power—

		Mean.
a.	92·57 at 17·8°	92·99 at 17·5°.
b.	93·40 at 17·2	

In this manner we have been able to reduce the suboxide in the copper by degrees: all the alloys made were fused in this manner, only substituting carbonic acid gas in cases in which hydrogen could not be employed.

We did not try to determine quantitatively the amount of suboxide present in the copper, as we know of no method which will give results which can be depended upon.* We shall only give the conducting power of copper that had been fused in contact with air. Thus copper, chemically purified, was fused with borax and chloride of sodium (the flux not quite covering the surface of the melted copper).

* Dick (Phil. Mag., June. 1858) could not obtain any good results by any of the known methods. All the experiments which we have made agree with his, especially concerning the action of ammonia on copper.

The conducting power of this specimen was

		Mean.
I.	*a.* 69·44 at 24°·2 *b.* 69·38 at 23·5 *c.* 69·30 at 24·0	69·37 at 23°·9.

This was then kept fused for several hours in a porcelain tube in a current of hydrogen; it then conducted—

		Mean.
II.	*a.* 87·20 at 18°·8 *b.* 85·50 at 19·0	86·35 at 18°·9.

This was next treated in the above described manner in the tobacco pipe, first for half an hour, and then for three hours, which caused the conducting powers to increase the following values:—

		Means.
III. After half an hour,	*a.* 89·32 at 17°·0 *b.* 91·07 at 17·8 *c.* 88·40 at 17·4	89·57 at 17°·4.
IV. After three hours,	*a.* 92·63 at 18·0 *b.* 93·36 at 19·2	93·00 at 18°·6.

Similar results were obtained with galvanoplastically precipitated copper, which had been fused in contact with air under a small quantity of borax and chloride of sodium.

		Means.
I. Fused in contact with air, . .	*a.* 73·20 at 19°·3 *b.* 73·08 at 19·4 *c.* 73·69 at 19·8	73·32 at 19°·5.
II. No. 1, fused in a tobacco-pipe for half an hour, as above described, . .	*a.* 76·27 at 17·6 *b.* 75·55 at 17·7 *c.* 75·38 at 17·8	75·73 at 17 7.
III. No. 1, fused one hour in pipe, . .	*a.* 83·14 at 16·8 *b.* 82·25 at 17·0	82·70 at 16·9.
IV. No. 1, fused for one hour and three-quarters in pipe, ...	*a.* 90·36 at 19·7 *b.* 91·00 at 19·7	90·68 at 19·7.
V. No. 1, fused for three hours in pipe, .	*a.* 91·92 at 18·5 *b.* 92·76 at 18·1	92·34 at 18·3

From the above experiments we see how difficult it is to reduce the whole of the suboxide; a fact which explains the reason why no good determinations as to the amount of oxygen present in copper have as yet been obtained.

2. *Effect of Carbon.*

According to Karsten,* copper takes up 0·2 per cent. of carbon; we could not, however, obtain wires containing more than 0·05 per cent. This small quantity causes the conducting power to decrease considerably. Thus, galvanoplastic copper in small pieces was fused down with lamp-black, and gave, upon analysis, 0·05 per cent. of carbon;† and for the conducting power we found

	Mean.
74·29 at 18°·1 75·53 at 18·5	74·91 at 18°·3.

* Schweigger's Journal fur Chemie u. Physik, lxvi., p. 395.

† We repeated this experiment several times, but could not again make the alloy. In all probability, therefore, the carbon found was only mechanically mixed with the copper.

3. *Effect of Phosphorus.*

Phosphorus alters the properties of copper to a very great extent; it becomes very much harder, and its tenacity is greatly impaired. Of all the impurities, this has the greatest reducing effect on the conducting power of copper.

Red phosphorus was thrown on melted copper in a tobacco-pipe and re-fused. The amount of phosphorus was determined as phosphate of magnesia.

		Means.
I. Copper with 2·5 per cent. of phosphorus, .	*a.* 7·37 at 17·0 *b.* 7·11 at 18·0	72·24 at 17°·5
II. Copper with 0·95 per cent. of phosphorus, .	*a.* 23·43 at 22·3 *b.* 23·05 at 22·0	23·24 at 22·1.
III. Copper with 0·13 per cent. of phosphorus, .	*a.* 67·88 at 20·0 *b.* 67·46 at 20·0	67·67 at 20·0.

4. *Effect of Sulphur, Selenium, and Tellurium.*

Sulphide of copper does not appear to dissolve in copper, but merely to mix with it mechanically. It makes the copper very brittle; and although we succeeded in drawing a wire which contained according to the analysis 0·18 per cent. of sulphur, the values obtained for the conducting power did not agree at all with each other. The mean of four determinations gave 88·58 at 19·4°.

Traces of sellenium and tellurium make copper so rotten that we were unable to draw it.

5. *Effect of Arsenic.*

When arsenic is thrown upon melted copper, the greater part of it is absorbed, whilst a part volatilizes; and on re-fusing the alloy formed, if a large quantity of arsenic has been used, it has a dingy grey color, and is very hard and brittle. We managed to draw an alloy containing 5·40 per cent. of arsenic to the diameter of 0·29 millim.; and had we had draw-plates with finer holes at our disposal, we might have drawn it much finer—a fact which does not at all agree with the assertions lately made, that copper with a small amount of arsenic cannot be drawn into fine wire. The arsenic was determined as arseniate of magnesia. The following values show that arsenic greatly reduces the conducting power of copper:—

	°	Means.
I. Copper with 5·40 per cent. of arsenic, .	*a.* 6·17 at 16.7 *b.* 6·19 at 17·0	6·18 at 16 8.
II. Copper with 2·80 per cent. of arsenic, .	*a.* 12·97 at 18·8 *b.* 13·38 at 19·4	13·14 at 19·1.
III. Copper with traces of arsenic, . .	*a.* 57·72 at 19 5 *b.* 57·89 at 19·9	57·80 at 19·7.

6. *Effect of Heating in a Current of Ammonia.*

Several experimenters state that, when copper is heated in ammonia, the gas is decomposed and nitride of copper formed, a fact which Schrotter* disputes, and has been proved totally incorrect by Dick.

* Gmelin, vol. iii., p. 416.

We repeated the experiment by heating a copper wire, whose conducting power had been previously determined, for a quarter of an hour in a current of dry ammonia: when cold, the conducting power was found the same, and the wire was as ductile as before. In all probability the reason why, in the experiments of previous observers, the copper became brittle, was (as already suggested by Dick) that they used copper containing suboxide.

7. *Effect of the Metals.*

The electric conductivity of copper is not so much impaired by the presence of small quantities of foreign metals as by that of the metalloids; it is, however, very considerably diminished by iron and tin.

The union of the copper with the other metals was effected in the manner before described, which offers in this case the additional advantage that, by the constant movement caused by the hydrogen in the melted metals, the most intimate combination results. The amount of the metals thus alloyed with the copper was determined by analysis.

		Means.
I. Copper* alloyed with 3·20 per cent. of zinc,†	a. 56·96 at 10°·0 b. 57·01 at 10·6	56·98 at 10°·3.
II. Copper with 1·60 per cent. of zinc,	a. 76·25 at 15·2 b. 76·45 at 16·4	76·35 at 15·8.
III. Copper with traces of zinc,	a. 85·67 at 18·0 b. 84·43 at 20·0	85·05 at 19·0.
IV. Copper with 1·06 per cent. of iron,	a. 27·44 at 14·2 b. 26·46 at 12·0	29·95 at 13·1.
V. Copper with 0·48 per cent. of iron,	a. 34·40 at 11·0 b. 34·72 at 11·4	34·56 at 11·2.
VI. Copper with 4·90 per cent. of tin,	a. 19·35 at 14·2 b. 19·60 at 14·6	19·47 at 14·4.
VII. Copper with 2·52 per cent. of tin,	a. 32·49 at 17·0 b. 32·79 at 17·2	32·64 at 17·1.
VIII. Copper with 1·33 per cent. of tin,	a. 48·76 at 16·8 b. 48·28 at 16·8	48·52 at 16·8.
IX. Copper with 2·45 per cent. of silver,	a. 80·01 at 19·6 b. 79·21 at 19·8 c. 78·93 at 19·8	79·38 at 19·7.
X. Copper with 1·22 per cent. of silver,	a. 87·61 at 20·6 b. 86·65 at 20·6 c. 86·46 at 21·0	86·91 at 20·7.
XI. Copper with 3·50 per cent. of gold,	a. 65·10 at 18·0 b. 65·80 at 18·2 c. 66·00 at 18·1	65·36 at 18·1.

We could not draw a wire of pure copper with only traces of lead in it, for it makes the copper to all appearance perfectly rotten; in Gmelin's 'Chemistry' it is also stated that copper which contains even 0·1 per cent. of lead cannot either be drawn into fine wire or rolled into thin sheets. Now the copper smelters add a small quantity of lead to their copper to soften and render it more tough. The addition of lead is supposed to reduce the suboxide of copper present; but,

* All wires hard drawn. † All the metals employed were pure.

according to J. Napier's* analysis, lead was always found present where it had been added, and often in quantities equal to the amount which had been put in. We have therefore made a few experiments in this direction.

To copper fused in contact with air, 0·1 per cent. of lead or tin was added, and the alloy fused in the tobacco-pipe in a current of carbonic acid gas.

		Means.
I. The copper employed conducted . .	a. 83·44 at 13°·0; b. 84·45 at 13·6	83 94 at 13°·3.
II. With addition of 0·1 per cent. of tin, .	a. 90 00 at 14·0; b. 89·80 at 14 0	89·90 at 14·0.
III. The same repeated, . . .	a. 91·27 at 13·8; b. 90·65 at 14·0	90·96 at 13·9.
IV. With addition of 0·1 per cent. of lead, .	a. 89·55 at 12·0; b. 89·42 at 13 8	89·48 at 12·9.

The quantity of lead and tin remaining was so small that it was not possible to determine it quantitatively.

The experiments, however, tend to prove that on the addition of traces of lead, &c., to copper containing suboxide, a relatively purer metal is obtained.

From the foregoing experiments, we may conclude that *there is no alloy of copper which conducts electricity better than pure copper;* and, in conclusion, in order to be able to compare their results with those of others, we would call the attention of experimenters—

I. To the importance of stating whether the wires experimented with are hard drawn or annealed, as it makes in some cases a very marked difference in the values obtained.

II. To the influence of temperature on the conducting power. We find in very few cases the temperature stated at which the observations have been made.

* Philosophical Magazine, S. 4, v. p. 488.

Trans. Royal Society.

The Smelting Furnace.

An ancient furnace-master in France, M. Joseph Bonne, has proposed certain modifications in the construction of iron-furnaces, which are highly lauded by the Editor of the *Cosmos*, and may be worthy of the consideration of our iron-masters. We give the substance of the article from the *Cosmos:*—

"In the present iron-furnaces, whose dimensions are too great, and whose height frequently reaches 45 feet, it is almost impossible properly to control the charges. The quantity of ore introduced is scarcely ever what it ought to be in relation to the fuel. If the charge is too small, the fuel is burned uselessly; if the charge is too great, the metal is white and brittle. Often the furnace is '*en debauche*,' according to the energetic expression of the workmen, and it must be *thrown out;* that is, the furnace must be emptied and suffered

to cool, and the work resumed under better auspices. Now these throwings out, which are repeated several times in a year, are ruinous. Under less unfavorable circumstances, we must at least wait twenty-four hours to know whether the modifications of the charge have produced the desired effect, and the furnace has been brought back to its usual condition. There is a general and just complaint of the ignorance and want of skill of the guards and chargers; but it is fair to acknowledge that the bad construction and exaggerated dimensions of our furnaces are an invincible barrier to the proper education of the workmen, and to their acquisition of a correct experience. Impossible as it is for them to understand the results which follow the arbitrary changes which they have thought proper to try, they allow themselves to be ruled by the furnace, instead of ruling it, and reason on nothing.

"The furnace of M. Bonne will never be over 27 feet in height; its content will be twenty charges of a cubic metre (35 cubic feet) each. Associated together in the service, the guard and charger will arrange with each other for feeding the furnace. As ten charges will be run, they will collect the product of the mixture made by them, and will see at once by the quality of the metal and the behavior of the furnace whether any thing ought to be changed in their management. In this way they will be compelled to learn their business; they will study it, and learn to work carefully and economically. To stimulate their zeal, M. Bonne requires them to keep a separate account of the fuel expended, and pays them in proportion to the quantity of metal produced. As the ore and fuel are for a long time the same, as each associated guard and charger run out the product of their own charge, judge for themselves, and see how their work is to be corrected, it is impossible that they should not arrive at a perfectly regular production.

"The principal innovation by M. Bonne is in the construction of the crucible. Rejecting the thick masonry which has continually to be built up and pulled down, which loses so much time in drying and in starting; he forms his crucibles simply of four stout curved plates of cast iron, firmly tied together from the bottom to the upper edges, and coated on the inside with fire-brick and clay. The cast-iron apron covers the whole front of the furnace, and is pierced with two holes, one below for the running of the metal, the other above, for the slag, which runs off of its own accord into a car, and is wheeled out when the car is full. The *estallages* are vaulted of fire-brick; the throat is entirely closed except the openings left for the gas-pipes, which are led to the boilers, or to the perpetual lime-kilns. A movable cover balanced by counter-weights is placed on top of the charge, to retain the heat in the furnace, and drive the gas into the tubes.

"M. Bonne is certain that these modifications will result in, first, an economy of more than 30 per cent. of the fuel consumed; secondly, an economy of 20 per cent. in the wages, by the reduction in the number of the workmen; thirdly, an economy of 50 per cent. in the expense of building, heating, and re-heating.—*Cosmos.*

On a Bathometer, or Instrument to indicate the Depth of the Sea on board Ship without submerging a Line. By C. W. Siemens.

From the Lond. Civ. Eng. and Arch. Journal, Nov., 1861.

Those who are acquainted with the difficulties and expense attending the taking of deep-sea soundings by means of a weighted line, will readily perceive that an instrument capable of indicating depths upon a graduated scale in the cabin of the vessel would be of great advantage, as a means of extending our knowledge of ocean geography. In laying submarine telegraph cables through deep seas, such an instrument would be invaluable.

It occurred to the writer that the total attractive force of the earth must be sensibly influenced by the interposition of a comparatively light substance, such as sea-water, between the vessel and the solid portion of the earth below. This he demonstrated geometrically as follows:—Assuming the earth to be a perfect sphere of uniform density, two lines are drawn from a point on the surface, so as to intercept the circumference at the semicircles. A line is then drawn through the two points of intersection, which passes through the earth's centre, and a second line parallel to it, touching the circle at its lowest point. It was next demonstrated, that in dividing the solid cone represented by these lines into a number of slices of equal thickness, in a direction perpendicular to its axis, each slice would exercise the same amount of attractive force upon a body at the apex of the cone; the reason being that the mass of each slice increases in the proportion of the square of its distance from the apex, and the attractive force diminishes in the same ratio.

It was thus demonstrated that the true centre of gravity of the earth in reference to an attracted body on its surface does not reside in its geometrical centre, but in a variable point between the centre and the attracted body. In dividing the sphere itself into slices of equal thickness a mathematical expression was obtained, representing the attractive force of any of these slices; and in integrating this expression for a series of slices it was the following formula:—

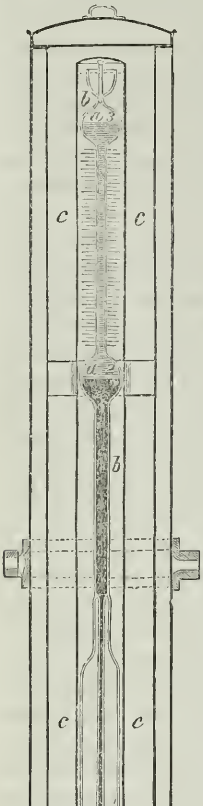
$$A_1 = 2\pi h\left(1 - \frac{2}{3}\sqrt{\frac{h}{2R}}\right)$$

in which A_1 signifies the attraction of the piece of the sphere sliced off, h the depth of this piece, and R the radius of the earth. In substituting $2R$ for h, the formula gives the total attraction of the earth, $A = \frac{4}{3} R\pi$, agreeing with Newton's formula.

Considering that the depth of the sea, which is represented by h, is exceedingly small as compared to $2R$, the expression $\sqrt{\frac{h}{2R}}$ may be entirely neglected, and the first formula may be written $A_1 = 2\pi h$.

Consequently, $A : A_1 = \frac{4}{3} R\pi : 2\pi h$, or, $A_1 : A = h : \frac{2}{3} R$.

For moderate depths the attraction of the earth may be represented by a very obtuse cone, with $\frac{2}{3}$ R for its height. If sea-water were of no weight, the total attraction of the earth would be diminished upon its surface in the proportion as the depth to $\frac{2}{3}$ R; but considering that sea-water has about one-third the weight (bulk for bulk) as the generality of rock, the actual diminution of gravitation was shown to take place in the proportion of the depth to the radius of the earth. Accordingly, 1000 fathoms of depth would produce a diminution by $\frac{1}{3200}$ part of the total gravitation, a difference so small, that it appears at first sight impossible to construct an instrument capable of indicating it with sufficient accuracy.



The second part of the paper described the instrument designed for this purpose, which consists of a tube containing mercury, diluted spirits of wine, and colored juniper oil. The mercury column, about 30 inches high, ascends in a tube from the bottom of a large bulb a^1, containing imprisoned air, and terminates in the middle of a second bulb a^2. The remainder of the second bulb is filled with the diluted spirits, which reach upward into a narrow tube provided with a scale. Upon this rests a column of the colored oil, which terminates in a third bulb a^3, the remaining space being vacuous, or nearly so. This gauge is inclosed in a glass tube *b b*, filled with distilled water, which in its turn is surrounded with ice, *c c*, contained in an outer casing: the latter is suspended by a universal joint. The air in the lower bulb, being maintained in this way at a perfectly uniform temperature, will oppose a uniform elastic force against the column of mercury, which latter, being removed from all atmospheric influences, fairly represents the gravitation of the earth.

In moving this instrument from shallow water upon a sea of 1000 fathoms depth, the mercury column would rise $\frac{1}{3200}$ part of its length in the second bulb; but before any sensible attraction has taken place in the mercury level, the upper surface of the spirits of wine terminating in the narrow tube will have risen sufficiently to restore the balance of pressure, and the spirits being 20 times lighter than mercury, the scale of observation would be increased twentyfold. But the spirit column, in rising, displaces oil of very nearly the same specific gravity, which causes another increase of scale at least twentyfold. By these means a scale of 3 inches per 1000 fathoms of depth is obtained.

An instrument of this description was tried by permission of the Admiralty, and although it was still imperfect in some respects, its

indications agreed generally within 10 per cent. with the results of actual soundings.

In the course of the discussion which ensued, Prof. Tyndall suggested that the instrument would be equally applicable for measuring heights.

Destruction of Insects in Grain. By M. Louvel.

In M. Louvel's plan, the grain is put into a hollow cast iron cylinder, from which the air is then exhausted. No animal can then live in it: fermentation itself stops, since it has neither air nor moisture, without which it cannot continue. On a large scale, M. Louvel makes his vacuum, by previously filling another cylinder provided with proper valves, with steam of four atmospheres pressure, and then condensing the steam. A communication is then opened between this generator, as it is called, and the cylinder containing the grain. A vacuum of 38 centim. (15 inches) is easily obtained and perfectly effective. Indeed, M. Louvel has found that 50 centim. (19·7 inches) was quite sufficient for the purpose.—*Cosmos.*

Cement for Rooms.

From the London Builder, No. 992.

A recent invention by M. Sorel is described to us. He states that the invention consists in the discovery of a property possessed by oxychloride of zinc, which renders it superior to the plaster of paris for coating the walls of rooms. It is applied in the following manner:—"A coat of oxide of zinc mixed with size, made up like a wash, is first laid on the wall, ceiling, or wainscot, and over that a coating of chloride of zinc applied, being prepared in the same way as the first wash. The oxide and chloride effect an immediate combination, and form a kind of cement, smooth and polished as glass, and possessing the advantages of oil paint, without its disadvantages of smell," &c.

For the Journal of the Franklin Institute.

Remarks on Mr. C. J. W., Jr.'s "Analysis of the Gamut in the Major and Minor Modes. By J. C. B.

To the Editor of the Journ. of the Frankl. Insti.

A friend having handed me a copy of your March No. containing an article "Analysis of the Gamut of the Major and Minor Modes," I desire to express my gratification on finding at least *one* scientific gentleman, so much interested in the "Art Divine" as to write a lengthy article on the subject. Although the conclusions of the writer are in the main just, yet the roundabout way in which he reaches them, is not, in my opinion, calculated to make them practical, which, after all, is the great desideratum in theory. I allow him, however, great credit for his originality. The immediate object of this communication is, to refer your readers to a work, viz: "The Introduction to the *Art* and *Science* of Music," by Phil. Trajetta, which is considered good authori-

ty on this subject. In its Preface we read, "There are systems of music like that of Tartini, so *entangled* with *mathematics*, that unless the reader is a *mathematician*, he cannot understand them." Also Less. xx. (2) "There are three principal sounds of the Diatonic Genus which are at the foundation of Harmony. These sounds are the *Tonic*, the fourth and the fifth or *Dominant*," and Less. xxii. (3) "When an alteration or diminution is given to the sounds of the Diatonic Genus, the key changes, viz: The musical phrase proceeds to another key. A sensible alteration would be that of the fourth, if made major (F to F sharp). A sensible diminution that of the seventh, when made minor, (B to B flat.)" These two propositions include all the theory of your correspondent. Hoping he may give us a more practical application of the subject, I remain, &c.

PHILADELPHIA, April 15, 1862.

Russian Method for the Preservation of Fruits, Vegetables, &c.

At the last Exhibition at St. Petersburgh, the following mode of preserving fruits, invented by the *maitre d'hotel* of the Grand Duke Nicholas, attracted great attention from amateurs. Quick-lime is slacked in water, into which four or five drops of creosote for each quart of water have been mixed: the lime must be neither too much nor too little slacked; there is a certain knack which practice alone can teach. Take a box and lay in its bottom a bed of the slacked lime, above this spread a layer of the materials to be preserved; at the four angles and elsewhere lay packages of powdered charcoal; then make another bed of the lime, followed by another layer of the fruit. When the box is full put on the lid, and close it air-tight. Thus preserved, the fruits will last a whole year.—*Cosmos.*

Proper Time of Year for Cutting Wood.

Four pine trees of the same age, equally sound, which had grown on the same soil and under the same conditions, were chosen. The first was cut at the end of December; the second, at the end of January; the third, at the end of February; and the fourth, at the end of March. They were shaped in the same manner, into beams of the same dimensions, and seasoned under the same conditions. Their resistances to bending were then determined by laying them on supports and loading them at the middle. The resistance of the first beam (that felled in December) being called 100; that of the second was 88; of the third, 80; and of the fourth, 62.

Similar results were obtained as to the durability and strength of posts made of sticks cut at the end of December and of March. The first were still perfectly sound after 16 years; the second at the end of 3 or 4 years broke with the slightest effort. All were buried in the same soil and under the same conditions.

Four oaks as like as possible, and placed in the same conditions, were cut at the end of December, January, February, and March. A disk of the same thickness was cut from each at the same height above

the ground, and was made the bottom of a vessel filled with water; the sizes of the vessel and height of the water being the same in all. The first (cut in December) allowed no water to pass; the others passed more or less; that cut in January, at the end of 48 hours; that of February, before the end of the second day; that of March, in two hours.

Two similar oaks were selected and felled, the one at the end of December, the other at the end of January, and staves made of the wood. Barrels were made of them, which were soaked in the same way, and then filled at the same time and with the same wine. In a year the barrel made of the wood cut in December had lost 0·14 quart, while the other had lost 7·2 quarts.—*Cosmos.*

Arsenical Pigments in Common Life. By Dr. A. W. Hofmann, F.R.S., Professor at the Royal College of Chemistry.

From the London Chemical News, No. 114.

The following letter has been addressed by Professor Hofmann to the Right Hon. W. Cowper:—

In accordance with your wishes, I have examined carefully the green coloring matter of the artificial leaves from a lady's head-dress which you have sent me.

It is well known that such leaves generally contain arsenic, and often in considerable quantities. An experienced eye readily recognises the presence of an arsenic color (Schweinfurt green) by its brilliancy, the intensity of which is as yet unrivalled by any other green. However, should there remain the slightest doubt, an experiment of the simplest kind would establish the fact. In most cases it would be sufficient to burn such a leaf in order at once to perceive the garlic odor which characterizes the presence of arsenic.

In a dozen of the leaves sent to me analysis has pointed out on an average the presence of ten grains of white arsenic. I learn from some lady friends that a ball-wreath usually contains about fifty of these leaves. Thus, a lady wears in her hair more than forty grains of white arsenic,—a quantity which, if taken in appropriate doses, would be sufficient to poison twenty persons. This is no exaggeration, for the leaves which you have sent me were, some of them at least, only partly colored, others only variegated. In consequence of your inquiries, I have been led lately to pay more than usual attention to the head-dresses of ladies, and I observe that the green leaves are often much larger and more deeply colored than those which I received.

The question how far arsenic-dyed wreaths may be prejudicial to health is intimately connected with the discussion, so frequently raised of late years, as to the influence which arsenic-colored paper-hangings exert upon the human system. This influence has been doubted on various grounds, both by the chemist and the physician. The alleged effect has been attributed to the development of arseniuretted

hydrogen, or some other volatile arsenic compound, to which the white arsenic, by the action of the damp on the wall, or of the organic constituents of the paper and the paste, might possibly have given rise. Accurate experiments, however often repeated and often varied, have proved the inadmissibility of the assumption of gaseous arsenic exhalations, and, as it so often happens, the injury was denied simply because it could not be explained. Nevertheless, the deleterious effect of arsenic green paper-hangings is at present pretty generally acknowledged. Indeed, it does not require any high-flown hypothesis to explain the transfer of the arsenic from the wall to the system. The arsenic dust, bodily separated from the wall and dispersed over the room, is quite sufficient for this purpose. The investigations of the last few years have clearly shown the presence of arsenic in the dust of rooms hung with arsenic-green paper, even when this dust had been collected at the greatest possible distance from the walls. Moreover, the chronic poisoning by arsenic of persons living in such rooms has been proved experimentally, inasmuch as the presence of arsenic may be demonstrated in their secretions, more especially if the elimination of the poison be accelerated by the administration of iodide of potassium.

The employment of arsenic green in the manufacture of paper-hangings ,in staining paper, in painting children's toys, &c., has attracted the attention of the sanitary authorities on the Continent for many years past. In several of the German States, more particularly in Bavaria, the very country of arsenic colors (which are manufactured on a very large scale in Schweinfurt, a town in Franconia), the application of these colors to papering or painting rooms has been repeatedly proceeded against. I have before me an edict of the Bavarian Government of July 21, 1845, expressly prohibiting the manufacture and sale of arsenic-green paper-hangings. This general prohibition, it is true, was repealed by an Act of January 23, 1848, "for industrial considerations," and the use of Schweinfurt green permitted as before for house papering and painting, provided the colors were permanently fixed by appropriate means. The relaxation of the measures against Schweinfurt green appears, however, to have given but little satisfaction. In several papers laid both by chemists and physicians before the Academy of Munich, in its sitting of June 9, 1860, undoubted cases of chronic poisoning produced by arsenic papers, even when glazed, were brought forward, and the Academy was called upon to represent to the Government the necessity of strictly enforcing the former regulations against arsenic colors, and of removing all Schweinfurt-green wall-coloring from public buildings, schools, hospitals, &c.

The immense consumption of arsenic colors, and their reckless use under various conditions prejudicial to health, certainly claim the especial notice and the consideration of the public. Not satisfied with poisoning the wreaths which adorn the heads of our women, modern trade introduces arsenic without scruple even into their dresses. The green tarlatanes so much of late in vogue for ball dresses, according to an analysis made by Professor Erdmann, of Leipsic, contain as

much as half their weight of Schweinfurt green. The color is loosely laid on with starch, and comes off by the slightest friction in clouds of dust. I am told that a ball dress requires about twenty yards of material—an estimate probably below the mark, considering the present fashion. According to the above analysis, these twenty yards would contain about 900 grains of white arsenic. A Berlin physician has satisfied himself that from a dress of this kind, no less than 60 grains powdered off in the course of a single evening.

It will, I think, be admitted, that the arsenic-crowned queen of the ball, whirling along in an arsenic cloud, presents, under no circumstances, a very attractive object of contemplation; but the spectacle, does it not become truly melancholy when our thoughts turn to the poor poisoned artiste who wove the gay wreath, in the endeavor to prolong a sickly and miserable existence already undermined by this destructive occupation!

Ladies cannot, I think, have the remotest idea of the presence of arsenic in their ornaments. If aware of their true nature, they would be satisfied with less brilliant colors, and reject, I have no doubt, these showy green articles, which have not even the merit of being, as far as coloring is concerned, a truthful imitation of Nature. There being no longer a demand for them, the manufacture of poisonous wreaths and poisonous dresses would rapidly cease as a matter of course.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, April 17, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from Col. S. H. Long, Bureau U. S. Topographical Engineers, Washington, D. C.

Donations to the Library were received from the Royal Society, the Royal Geographical Society, London, and the Literary and Philosophical Society, Liverpool, England; the Bureau of Topographical Engineers, Washington City, D. C.; Prof. Daniel Treadwell, Cambridge, Mass.; William Bryson, Esq., and J. Spencer Turner, Esq., Chicago, Ill.; the Board of Water Commissioners, Detroit, Mich.; the Young Men's Mercantile Library Association, Cincinnati, Ohio; and George M. Conarroe, Esq., and Prof. Frazer, Philadelphia.

Donations to the Cabinet of Models—from L. C. Francis, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of March was read.

The Board of Managers and Standing Committees reported their minutes.

Three resignations of membership in the Institute were received and accepted.

Candidates for membership in the Institute (9) were proposed, and the candidates proposed at the last meeting (2) were duly elected.

Mr. T. Fisler exhibited a Feed-Bag for horses. It consists of a feed-bag of the ordinary form, to the bottom of which can be attached at pleasure a jointed rod, which may be folded up with the bag so as to readily pack to the saddle when not in use. A strap passes over the head of the horse so as to hold the bag in position, the end of the jointed rod resting upon the ground and supporting the bag, so that the animal can obtain all the feed that is in it without tossing it up, as is necessary with the form of feed-bag usually employed. This is particularly useful for cavalry, or those who carry their horse-feed with them, in traveling.

Mr. Edward Longstreth exhibited and explained a patent Oil-Can for oiling valves and pistons while under pressure, without cutting off the steam; also, some specimens of malleable Horse-shoe Nails, made by machinery invented by Mr. William C. Grimes, of Philadelphia.

Mr. Charles S. Close exhibited a Stove for army purposes, having the plates united by scroll joints, which may be folded up when not in use, so as to occupy but a small space.

Mr. L. O. Colvin exhibited the Lamp and Apparatus of an Optical Telegraph, patented by himself and G. H. Gordon, March 11, 1862, and remarked, that a light made to appear and disappear, corresponding to the dots and dashes of Prof. Morse's telegraphic alphabet, can readily be used as a means of communication as far as the light can be seen, the distance depending upon the strength of the light used. But in order to make telegraphing in this manner *successful*, certain things are essential. A strong, regular light must be produced, and so arranged that the light be made to appear and disappear suddenly and with ease in signaling the letters.

The invention combines a lantern and reflector, provided with a shutter operated by hand or by electro-magnetism. The lantern is built to produce the best possible light from the substance consumed, protecting the flame from outside currents of air, retaining the heat by the use of plaster of paris, and also supplying the burner with a constant and copious quantity of air; the whole tending to secure the most perfect combustion. The brilliant light thus produced is used to the greatest possible advantage; the best rays of light proceeding from any flame are the direct rays and those adjacent; these are secured. A reflector made in the shape of a horn or funnel is placed wholly in front, with the small end to the light; the direct rays pass through unobstructed, while the reflected light is reflected so near its source and bent so little from its direction as not to diminish its intensity. The real light appears in the centre, encircled with a perfect halo of reflected rays, throwing in front a light the full size of the large end

of the reflector, appearing at a distance like a perfect ball of fire. Having the cut-off, as you see, at the small end of the reflector, it becomes very easy to expose the light to view in making the signals with facility—since the shutter is so small and light, and the distance it is necessary to move it is so short, being only to uncover the size of the flame—thus gaining the advantage of a large light, though working a small cut-off, which could not be done by any other style of reflector. By this construction the letters can be signaled perfectly,

o	*p*	*t*	*i*	*c*	*a*	*l*,
(- -)	(- - - - -)	(—)	(- -)	(- - -)	(- —)	(——)

and read with all ease by any telegraph operator. The shutter can be easily worked by hand, or better by electricity. An electro-magnet placed so that its armature, attached to the lever of the cut-off, by being attracted to the magnet, opens the shutter; by making and breaking the current with the battery, the light is exposed to view as desired. Thus making it still more easy to operate, telegraphing by light becomes the same in operation as by the common telegraph. The lantern thus constructed can be placed at any convenient position—the mast-head of a ship, top of a tree, or tower of a lighthouse—and worked from below at the pleasure of the attendant. Another operator at a distance reads the letters as they are signaled, and copies down the message.

There is no difficulty in telegraphing secret messages. If you remove the vowels from a page of reading, what can you make of it? Nothing. Our plan is to arrange the letters *a e i o u w y* in a table, with figures to represent them; the arrangement can be used 49 different ways, and can be changed at any time. Used in this manner, write off the dispatch, make the substitutions, and give it to the operator; it is sent and received as given, and taken to the person for whom it is intended; he having a key, makes the substitutions back again, and reads the message—the operators knowing nothing of the import of the message they have telegraphed. *Optical* by one substitution might appear thus: 4pt2c5l.

Light in many respects is as well adapted for telegraphic purposes as electricity; it is as fleet in its journey, and with an apparatus constructed to suit its nature, it will do its work as rapidly and distinctly. By this plan a system of communication can be established along our whole coast *via* the ships of war and the lighthouses, by which messages may be sent and received from any portion of our blockading fleet every night, with just as much certainty and despatch as if a cable connected the different points and the electric flash conveyed the intelligence.

Mr. E. L. Snow exhibited Haley, Morse, & Boyden's machine for squeezing the water from washed clothing, termed by them, "Self-adjusting Clothes Wringer." It consists of a wooden frame carrying two rollers of vulcanized india rubber, rolling together and kept in close contact by levers and gum springs. The frame is arranged so as to be clamped to the wash-tub, and motion is given to the rollers by a

crank handle. A piece of washed clothing can have one end or a corner inserted between the rollers, which, when turned, draws the piece through from the tub and delivers it into a basket placed to receive it, whilst the extracted water falls upon a piece of wood fixed beneath the rollers, and inclined towards the wash-tub, in order to convey the water back. It is claimed to be a quicker and less injurious process than that of wringing, and that buttons or hooks and eyes pass through without injury to themselves or to the rollers.

It is also claimed that the twisting or wringing of clothes stretches and breaks the fibres; but this machine presses them so evenly that a newspaper thoroughly soaked can be squeezed without breaking it in the least, and it works so easily that a child twelve years old can operate it without trouble. Hot water does not injure the rolls, and woolen goods can be squeezed out of boiling water when used to prevent fulling, which cannot be done by hand.

In starching, it is valuable, especially on large articles, such as ladies skirts, &c., as it leaves the starch in the clothes perfectly even. It will squeeze the largest bed quilt or the smallest pocket handkerchief, dryer than can possibly be done by hand, without alteration, in less than one-eighth the time. The machine is so simple that it cannot get out of repair.

The great improvement in this water extracting machine is its self-adjusting arrangement, requiring no alteration to wring a hankerchief or bed quilt, consequently the most ignorant servant can operate it.

The machine being made of wood, is so arranged that no iron can possibly come in contact with the clothes, thereby avoiding all danger of injury to the clothes by oxide of iron.

Mr. A. L. Fleury exhibited apparatus and made the following remarks:—

Since Professor Faraday introduced the electric light in the lighthouse at South Foreland, near Dover, sending its intense rays through the dense fog, across the Channel, over a distance of twenty-seven miles, distinctly visible from the tops of the lighthouses on the French coast, the use of the electric light is becoming more and more extended over Europe; and, judging from certain indications, we may safely infer that the electric light will soon become successfully introduced into this country.

Nothing, in the way of light, has yet been produced that can compare with the beauty and brilliancy of the electric light; it converts, as we may fairly say, midnight into noonday.

Applied on steamers and vessels, immense advantages for the safety of the public, and for insurance companies, will be derived, preventing the very frequent collisions at sea. Along dangerous coasts, during the winter months, how many ships are lost, how many lives are sacrificed, how many valuable cargoes are destroyed, from the want of a light sufficiently powerful to burst through the thick midnight haze of the storm, and warn the voyager of the hidden dangers ere it be too late! For coal oil factories, where lately even the best

safety lamp has been found to fail, as the exceedingly fine benzole vapors may take fire through the finest wire gauze, the electric light, entirely excluded from the atmosphere, will be safe, and, therefore, preferred to all other lamps. The same in mines, where, by a series of reflectors, the light can be thrown from shaft to shaft, or, by properly adjusted guide-wires, be slid down into the deepest mine. The interior of gunboats, rams, and diving-bells can thereby cheaply and safely be illuminated, proof against air and water. The storm may rage, the spray may dash over the ship, it cannot extinguish the electric light; placed under water, it will still burn, and throw its magnificent rays around it. There is no danger of explosion—no escape of nauseous gas.

Having shortly discussed the safety and adaptability of the electric light, we will now proceed to the most important point—the one of comparative cost. Prof. Faraday, to whom we are indebted for the first practical introduction of the electric light, gave preference to the magneto-electric machine over the use of the galvanic batteries, as being the least troublesome and most economical source of electricity. The following comparison will enable us to judge:—*To produce an electric light equivalent to* 800 *wax lights, it will require* 50 *couples of Bunsen batteries, of a large size, the expense of which for consumption of zinc, mercury, and acids, would be about three dollars per hour; while with the magneto-electric machine the same production of light will not cost more than* SIX CENTS *per hour; and even this cost can be still reduced, if, in place of steam, a water course or windmill is employed.* On steamboats, or in factories, mines, &c., the cost of the motive power for producing the electric light would be near to nothing, as there is always sufficient power to spare for this purpose.

When a rotary movement is given to the magneto-electric machine by any power whatever, *it instantly produces a current of electricity of a perfect regularity and continuity*, and this current can be regulated with the greatest facility to the degree of quantity and intensity required.

The machine has, moreover, the advantage of being always ready to work; this gives it a new superiority over the battery. Above all, when a certain number of elements are employed for putting the battery in movement, it entails so great a loss of time, that the agents of transformation are used for the first couples in action, before the last are ready to work.

Such is, under the threefold advantage of *power of production, lowness of price*, and *economy in time*, the greatness of the progress accomplished by the magneto-electric machine. The model of Baker's patent machines, now exhibited before the Institute, constructed by Messrs. Collier & Co., at Binghampton, N. Y., seems to me in every respect the best adapted for all purposes for which a larger quantity of dynamic as well as static electricity is required. A full description of this machine, with a fine engraving, will be given in a future number of the *Journal of the Franklin Institute.*

Comparing the several devices of electric lamps, models, and dia-

grams, which are here exhibited to the members of the Institute, we find those of Prof. Way, known as the Mercury Light, described in the *Journal of the Franklin Institute* for April, 1862, and those patented by Messrs. Henry M. Collier and Henry N. Baker, to be the best adapted and most economical of all. The former having been described before, I will now explain the construction and merits of the latter.

The invention consists, first, in certain means of controlling the positions of the electrodes, by which they are kept properly in contact with each other, as they wear away by the disengagement of the particles, without the difficulty experienced in keeping up a proper degree of separation between them. To produce a light in this way has generally been supposed to be impracticable; but the inventors, by long-continued experiment, have found that by employing an electric current of very low intensity, but large quantity, they are enabled to use the points in contact. The difficulty of keeping the carbon electrodes pointed has resulted from particles of carbon being carried over by the current of electricity from the positive to the negative pole of the electrodes. With a view to obviate this (viz: the depositing of particles from the positive unto the negative pole), the invention also consists, secondly, in frequently reversing the direction of the current. To obtain this change of direction, the current of electricity evolved from a magneto-electric machine is used without the intervention of a frotteur or brake-plate, or else the current from a galvanic battery can be used—there being arranged in the circuit a brake-plate or pole-changer, which is rotated by electricity, by clock-work, or by any suitable mechanical means to produce a frequent change in the direction of the current. This invention, dispensing with expensive machinery, is a valuable contribution to applied science, and will do much towards rendering this most brilliant light available.

In the production of electric light, preference has generally been given by scientific men to the employment of carbon electrodes, and these mostly in the shape of pointed pencils, as giving the most brilliant and desirable light; but so much difficulty has been heretofore experienced in securing the proper relative positions of the pencils, and in keeping them pointed, that electricians have been forced to very ingenious but expensive and often complicated mechanical appliances, to obviate these, the only apparent objections to the use of the desired carbon electrodes.

Any one who has examined the complicated mechanism of former electric lamps, must be struck with the remarkable simplicity and perfection of the apparatus originated and constructed by the Messrs. Collier and Baker, which secures most accurately the adjustment of the carbon points. Dispensing with all gearing, springs, screws, electro-magnetic regulators, or other complications, its simplicity is only equaled by an ordinary candlestick, and its appearance is about as unassuming.

The main feature of this lamp is a hole in a metallic strap or bridge,

which secures the position of the points, and regulates the feed or supply as fast as consumed. The carbon pencils being in vertical positions, the upper one is fed down by gravity, and the lower one as a float is fed up by its own buoyancy. The hole or orifice in the upper metallic strap or bridge, is of a diameter a *little less* than the body of the pencil, so as to permit a portion only of the point to pass through, and as fast as it is reduced in size by the oxidation and disengagement of particles during the process of combustion. The pencil is thus gradually and surely fed downwards, and the feed regulated and controlled by its own combustion.

Using an electric current of *large volume* and *low intensity*, as the Messrs. C. and B. much prefer, the electrodes may remain *in contact;* then the hole in the lower strap, being the same size as the body of the lower pencil, acts as a perfect guide to the pencil as it passes up through it, and the lower pencil resting its point against the point of the upper pencil, is thereby controlled in its feed upwards.

Using a current of *high* intensity, it being desirable to *separate* the *points* and maintain that distance, the feed of the lower pencil is regulated and controlled by reducing the size of the hole in the strap to correspond with the upper one, and for the same purpose.

Using a current of electricity constant in one direction, there is a tendency to an accumulation of particles of carbon on the negative electrode, and a consequent blunting of that point. To avoid this, the Messrs. C. and B. use a *to and fro current.*

In this invention the extremes of simplicity and cheapness are combined; the cost of the original lamp, and the one used by the Messrs. Collier and Baker in their experiments, was the paltry sum of $2·50. What can be cheaper, more simple, and yet efficient?

Having been long in pursuit of the cheapest and best electric lamp, for the production of a uniform, reliable, and brilliant light, I shall venture to write upon this one "Eureka."

We will add here another important application of the electric light, and speak of

Photo-Telegraphy.—Man, after having succeeded in securing the services of electricity as his messenger of thought, impressed another agent, swifter still than electricity—Light! Signals with lights have been known from time immemorial, but a regular system of telegraphing with flashes of electric light, is comparatively new, and of great value in field operations. The apparatus here exhibited to the members of the Institute, is the invention of Mr. William C. Bridges, of this city. It consists of a tube, containing a lens and one or more adjustable mirrors, in combination with such devices as will obscure or expose the lens, which is illuminated by the electric lamp or rays of the sun, reflected from the mirrors, or for moving differently colored plates of glass to the front of and away from the lens, so that on observing the latter from a distance, its exposure and obscuration, or the different colors seen, will be the means of informing the observer of the nature of the messages transmitted by the operator. It can easily be observed that any kind of signals may be transmitted at a distance of twenty

miles at a medium, and of fifty to sixty miles at a higher elevation; for instance, from one high mountain-top to another; but for these distances it is necessary to use a telescope attached to the frame of the apparatus. To interpret Morse's telegraphic alphabet, the signals must be guided by the length of time during which the lens remains obscured, and by the rapidity of the movements given to the disks, precisely as if guided by the ticks of a telegraph instrument. In some cases, for instance, in time of war, a secret system of signals, predetermined by the operators, may be used. Thus, flashes of light may be made the messengers of thought in such localities where the transportation of telegraphic wires and instruments are too expensive and impracticable. Every vessel should be provided with a *light* telegraph and a small steam-whistle, as by these means she would be enabled to correspond and signal at night, and at such distance where no other signs of intelligence can be discerned.

There is little doubt but that the application of magneto-electric machines for the production of light, and for all purposes where a large amount of electricity is required, will soon supersede the use of galvanic batteries. A few words relative to the importance of this machine for the *ordinary telegraph* may here not be amiss:—

The extent of telegraphs in the United States is increasing every day; the capital involved is upwards of *six millions of dollars.* To work the telegraph lines, it takes annually 720 tons zinc, worth $60,000; more than 1,000,000 pounds nitric acid, worth $120,000; and $30,000 worth of mercury; besides a considerable amount of sulphuric acid, &c.; *none of which are used by the magneto-electric machines for generating electricity* (a uniform and steady current being produced by Mr. Baker's last improved arrangement), *thereby giving them immense advantages over the galvanic batteries, both in economy and time.*

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.

March.—The mean temperature of March, 1862, was about 3½ degrees below that of the same month of 1861, and 2° below the average temperature of the month for eleven years.

The warmest day of the month was the 12th, of which the mean temperature was 48·3°. The thermometer reached its maximum (56°) on the same day.

The coldest day was the 1st, with a mean temperature of 32·3°. The minimum (22°) was reached on the same day.

The range of temperature for the month was 34°.

The temperature was below the freezing point on 14 days of the month, but it rose above that point in the course of the afternoon of every day.

The greatest change of temperature in the course of one day was 22°, on the 30th day of the month; the least was 6°, on two days, the 14th and 15th. The average daily oscillation of temperature for the month (14·44°) is still below the average.

The greatest mean daily range of temperature was 8·7°, between the 12th and 13th of the month; the least was 1·2°, and occurred four times, between the 1st and 2d, between the 14th and 15th, the 21st and 22d, and the 22d and 23d. The average daily range for the month was only 3·95°, which is $4\frac{1}{2}$° less than for March of last year, and more than 2° below the average for eleven years. It was the smallest mean daily range observed in any March during the eleven years of observation. The nearest approach to it was 5·3°, in March, 1856.

The pressure of the atmosphere was greatest (30·173 inches) on the 9th of the month; and the greatest mean pressure (30·156 inches) occurred on the same day. The pressure was least (29·276 ins.) on the 3d. The least mean pressure for a day (29·390 ins.) occurred on the 16th. The average pressure for the month (29·782 ins.) was eleven-hundredths of an inch below that for March, 1861, and four-hundredths below the general average for eleven years.

The greatest mean daily range of atmospheric pressure was 0·447 of an inch, and occurred between the 14th and 15th days of the month; the least was 0·032 of an inch, between the 29th and 30th. The average mean daily range for the month (0·173 in.) was two-hundredths of an inch less than the average for the month of March for eleven years.

The force of vapor was considerably less than usual. It was greatest (0·389 in.) on the 10th, and least (0·081 in.) on the 26th of the month. The average for the month (0·159) was two-hundredths of an inch less than the general average.

The dew-point was highest (47·9°) on the 10th, and lowest (16·6°) on the 27th.

The relative humidity was greatest (95 per cent.,) on the 3d and 15th days of the month, and least (25 per cent.) on the 27th. The average humidity for the month was 6 per cent. greater than for March, 1861, and a little over 2 per cent. greater than the average for eleven years.

Rain or snow fell on eleven days of the month, to the aggregate depth of 3·509 inches, which is a little less than the amount which fell in March, 1861, but nearly two inches more than the average for eleven years.

There were but two days of the month, the 1st and the 7th, entirely clear or free from clouds at the hours of observation, and the sky was completely covered with clouds at those hours on nine days. The average amount of the sky covered with clouds during the month of March, 1862, was about 65 per cent.; during March, 1861, it was 57 per cent., and the average amount for eleven years is but 54 per cent. of the hemisphere.

On the evening of the 12th of the month, a lunar rainbow was visi-

ble. It was about 8 or 9 degrees in diameter, and the colors were very distinct.

A Comparison of some of the Meteorological Phenomena of MARCH, 1862, *with those of* MARCH, 1861, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich.

	March, 1862.	March, 1861.	March, 11 Years.
Thermometer.—Highest, . .	56·0°	78·5°	78 5°
" Lowest, . . .	22·0	16·0	4·0
" Mean daily oscillation,	14·44	18·18	14·98
" " daily range, .	3·95	8·66	6·14
" Means at 7 A. M.,	34·24	37·73	35·77
" " 2 P. M., .	44·21	48·71	47·18
" " 9 P. M.,	39·18	41·58	40·58
" " for the Month,	39·21	42·67	41·18
Barometer.—Highest, . . .	30·173 in.	30·386 in.	30·522 in.
" Lowest, . . .	29·276	29·354	29·158
" Mean daily range, .	·173	·231	·193
" Means at 7 A. M., .	29·804	29·917	29·848
" " 2 P. M., .	29·747	29·862	29·792
" " 9 P. M., .	29 795	29·906	29·827
" " for the Month,	29·782	29 895	29·822
Force of Vapor.—Means at 7 A. M.,	·149 in	·175 in.	·164 in.
" " " 2 P. M.,	·159	·182	·180
" " " 9 P. M.,	·171	·185	·181
" " " for the Month,	·159	·181	·175
Relative Humidity.—Means at 7 A. M.,	74·4 per ct.	69·3 per ct.	73 6 per ct.
" " " 2 P. M.,	56·2	47·9	52·9
" " " 9 P. M.,	70·5	65·7	67·7
" " " for the Month,	67·0	61·0	64·7
Rain and melted snow, amount .	3·509 in.	3·903 in.	2·773 in.
No. of days on which rain or snow fell,	11	9	10·3
Prevailing winds—Times in 1000-ths,	N.43°7′ W.·377	N.73°37′W·328	N.72°51′W·313

BIBLIOGRAPHICAL NOTICE.

The Vine-Yard: devoted to Grape Culture. Published by WM. P. PECK and WM. ROWE, 11 Exchange Place, Jersey City, N. J.

We are glad to see that the subject of grape culture has attracted such attention as to render it advisable to have a journal devoted to it as a specialty. Recent events have shown us how important it is that we should render ourselves as far as possible independent of all foreign countries for our supplies. And there are few manufactures (exclusive of those of absolute necessity, such as food, clothing, and iron,) which are of more importance to the health and moral improvement of our population than those which depend on the culture of the grape as their base. We wish the new comer a deserved success, and hope his shadow may increase over the land. F.

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

JUNE, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By Samuel McElroy, C. E.

(Continued from page 297.)

No. 1.—Reservoir Construction—(Continued).

Theories of Construction.—The object in presenting this rapid sketch of ancient and modern practice, is not for the purpose of describing the several details of arrangement, but rather to illustrate certain general and important principles which have been seriously neglected, and need to be specially recalled.

As to the use of reservoirs, it is obvious for many reasons, which we need not pause to discuss, although involving interesting questions, that between the practice of the ancients and many moderns, in the resort to street fountains, or small house cisterns at low levels, and the system of intermittent supply, as in London, and the service with adequate distribution, under constant pressure, as with us, safety, convenience, and method strongly favor the latter. All the losses which it may involve in supply are fully compensated by attendant benefits, and these may themselves be guarded with proper care.

But the principles of arrangement which we may derive from and add to the practice of the ancients, may properly demand our first attention.

There is a general, and perhaps natural, popular impression, that

water, from our familiarity with its flow in large and small quantities, its common use, its value as a beverage, and its cleansing properties, is easily controlled and confined, and essentially clean and pure; but the engineer who has had to struggle with its enormous weight, its insidious and incessant, or its abrupt and overwhelming energy, its exquisite mobility and its wonderful solvent power, and who has studied the constituents of its natural state and the laws of its purity and impurity, understands the fallacy of this popular idea.

It is evident also, that nothing new has been learned on this subject, in hydraulic theory, and not much improvement has been made in practice, since the Jewish monarch, Hezekiah, distributed, *under pressure*, the supply of Gihon into the city of David. New combinations of old things characterize present professional practice, much of which, as we propose to show, is degenerate.

All hydraulic constructions of the ancients were exceedingly substantial in character, many of them yet remaining in use. Their *castellæ* and *cisternæ*, as their aqueducts, testify to-day of the care exercised in stone and brick, in cement mortar and lining, and in proportions of construction. This may be defined as one prominent characteristic, which illustrates their knowledge of the element they intended to subdue and confine. As a second point, it may be noticed that their aqueducts and reservoirs of all classes were carefully covered; that distinctions in use were made in the qualities of water supplied; and that provisions were made for depuration.

We also observe that the scale of reservoir capacity has been greatly enlarged in modern times, involving a necessary change in materials; and that in the European school, and a few instances with us, reservoirs in earth-work, with artificial slopes, at less than the angle of repose, are protected by substantial water-tight lining. But these instances are rare, being the exceptions to a rule which cannot be approved, and which in practice has universally condemned itself.

The principle of constant service in itself involves the use of reservoirs of great capacity, since the consumers are not prepared for any loss of supply; the use of earth embankments for such reservoirs is in several respects advantageous, and a regard for economy in space and cost favors the use of artificial slopes. As constant service also requires elevated reservoir location, where losses and accidents are enhanced in importance, the question of propriety in construction with us is national. This question has two divisions—proper *stability* and proper *depuration.*

Stability.—All earth-work of artificial slopes in contact with water is exposed to absorption and solution under static pressure, a condition increased by relative head, and is readily disturbed when exposed to water in motion. Either action is injurious, and should be prevented. The solvent and penetrating power of water on an embankment is liable to produce threads and eventual streams of leakage, against which provision must be made. For this purpose puddling is applied. But puddling being in part or wholly composed of clay, is itself pecu-

liarly liable to destruction from water in motion, and hence requires protection; and a very common practice is, to place heavy pyramid walls of it in the centre of embankments, by which the preserver of the earth is to be preserved by earth. This involves an error in principle, since the earth embankment, from its peculiar properties of resistance, is what is relied upon to sustain the enormous thrust of the water prism, and its figure ought not to be thus divided into three distinct bodies and states of body with two distinct kinds of material, of which the face of the centre body is so formed as to thrust the inner embankment towards the foot of the slope, in case it has any tendency to motion from saturation or otherwise. There is no propriety then in placing puddle walls *within* an embankment, for the protection of the embankment, nor is there any propriety in building the base of a puddle wall on the materials it is intended to protect, if such base is not extended over the water floor of the reservoir, so as to prevent leakage precisely where the greatest pressure makes it most apt to occur. Especially is it erroneous to build the foot of a puddle wall on a rock face, along which water readily finds its way; as water joints cannot be made between smooth rock faces, or wood, or iron, and clay, with any degree of certainty.

Evidently, then, the stability of a reservoir of this kind depends, as to this point, on the integrity of its embankments, and these cannot be protected except by absolutely water-tight facing as to the inner slopes, and flooring as to the bottom, and for such facing puddling is not in itself sufficient.

The stability of a reservoir is affected by the relative force and volume of its inlet and outlet currents; by the saturation of its inner slopes, which exposes them to the action of frost, to diminished solidity, to slides, and to leakage; by the action of surface waves, which act as breakers, and are created and affected chiefly by the force and direction of winds, by area or length of travel, by relative shallowness of depth, and to which broken ice at times adds abrasive power; and by the action of muskrats and other animals of the kind. These several actions apply to the bottom, the slopes, and the top angles, as also to the embankment prisms.

The use of dry slope walls is, therefore, defective in principle, since they freely admit the passage of water into the banks, with all the effects of saturation, solvency, currents or waves, which such an open structure cannot but transmit, either to puddling or earth-work, to a greater or less extent. It is only in modification of effect that they are beneficial, and these benefits depend on their thickness and tightness, and the relative power of injury the water may have, under ordinary or extraordinary contact and agitation.

Puddling carefully made, from proper materials, and worked dry, is in itself, as a compact, homogeneous body, admirably adapted for transmitting to the prism slope of an earth embankment on the planes of its surface, when itself properly built or filled, the thrust of the water prism; and when thus laid on the slope, it can be very conveniently and certainly united with the floor covering; hence, the

eminent propriety of its use in this way, and for this purpose. And from the obvious necessity of its protection from the water, follows the use of cement masonry, of solid and durable character, over its entire exposure.

The instances which abound in illustration of this theory of absolute protection, based on the best ancient and modern practice, ought perhaps to be discussed at length, but will be grouped here for the present. Of the list of United States reservoirs presented, only the first four are free from grave objections on this point in construction. When it was attempted in 1854 to draw down the Brookline reservoir, the saturated banks followed the water; when the Hartford reservoir was filled in part, the east bank slid out, forming a new slope, which was in part retained; when Ridgewood reservoir, in 1859, was filled less than 7 feet deep, the surface waves, under March winds, washed out the puddled and earth backing, so as to require the entire rebuilding of a wide belt, before the wall could be subsequently pointed, an event which changed the lining of the new Croton reservoir; in the Manhattan reservoir, as to its walls, a glance reveals the effect on the banks, although changes of water level are rare, and for the system of puddling, occasional rivulets of leakage on the ends, and the necessity of a large sewer on Fifth Avenue, are sufficiently argumentative; the Detroit reservoir, in 1859, which had embankment puddle walls, with a light and imperfect brick face, being drawn down because the upper bank was weakened, brought down the entire embankment face with it, and after considerable consultation, a massive stone abutment was built at the foot of the slope, and a dry stone wall, 6 feet thick at the base and 2·5 feet at the top, carried up, for the ostensible purpose of holding the slope in its place!

From these and other facts, which might be much more fully collated, and which are comments on a simple theory, it may be taken for granted, that no reservoir is properly constructed which is not water-tight in every direction subjected to pressure, and which is not fully protected as to its puddling and earth-work by substantial cement masonry; nor does the fact that such light covering as that of the Belleville, the new Fairmount, and other reservoirs, serves its purpose so far well, justify the hazard which is incurred in its use.

As in slope puddling it is necessary to use thickness enough to make a convenient working width, and as it is advisable in hydraulic work to avoid prolonged bed joints, and as 8 inches of brick masonry can be made much tighter than several times its thickness of stone, while the same thickness does not double the cost, I have preferred to use for reservoir slopes, two feet in puddling, faced with a layer of concrete, and covered with 8-inch brick-work, carefully coped, and adopted this plan for the contract of the Brooklyn Water Works in 1856, covering the bottom with the same thickness of puddling, with 4-inch brick paving, grouted. And with hard-burned paving brick, properly selected and laid in close joints, such lining must prove very satisfactory. The same principle may, however, be fully sustained with carefully built rubble masonry.

Depuration.—Not only does the ancient and the best modern practice use substantial cement masonry in reservoir lining, but with the former, as shown at Rome, Constantinople, Utica, &c., and to an important extent with the latter, as in the new Chelsea Company reservoir, and others which might be adduced in the European school, the water is carefully protected from the sun, and provisions are made for purification by filtration or otherwise.

In all natural water there are three classes of impurities, which differ in different localities, only in degree, and these are, the *mechanical*, the *organic*, or vegetable and animal, and the *mineral*. Chemical science, which has devoted much attention to this subject, and the abundant results of experience have shown, that subsidence corrects the first class of impurities, that æration and fermentation correct the second, while the third may be modified by æration and filtration. From these leading principles we understand at once, that while all reservoirs are depurative by subsidence, as well as by filtration if used, and therefore tend to collect these heavier constituents, none properly fulfil their office in this respect which do not furnish for consumption a surface supply, and their value for subsidence depends on their relative storage and method of use. We also understand that heat, light, and air are the prominent agents on organic matter in water, which is also collected in reservoirs on account of its specific gravity, and that it is therefore advisable to prevent so noxious a condition as direct fermentation to a sensible degree. The third class is not so easily affected, but may be moderated in degree by the remedies for the others.

We see then that subsidence, filtration, circulation or æration, and exclusion of light and heat, are the correct processes for water depuration and preservation, and that the surface currents are of necessity the most pure, while the lower strata are of necessity the most impure. And we therefore comprehend the philosophy of the expensive provisions to these ends, adopted in ancient and modern hydraulic practice. It is a question of great moment to determine how far, in our own school of economical engineering, these provisions are or may be observed.

For the extensive scale of many of our works, the use of covering, which ought never to be cheap and temporary, is almost beyond attainment on the ground of cost; while we know that it would maintain coolness in temperature and freedom from storm waves. It is also plain that filtration by artificial means is in itself an expensive and unsatisfactory process on any large scale, from the necessity of constant renewals, if the process is at all complete in action; although filter beds like those in action at Glasgow and other places are simple in construction, are easily renewed, and do not add over one-half cent cost per thousand gallons for annual operation and interest of capital. The reliance, then, of our own school is confined to subsidence and circulation.

Examining the systems of reservoir construction and use, with us, we have by no means a gratifying series of evidence that due precautions have been exercised in this respect. The use of distinct divisions

is the exception rather than the rule, and very rarely does it occur that consumers are supplied with surface water, which is the purest, but as a general rule, the reverse is the case, and the very process of subsidence carries into the pipes water much more impure than that of the fountain head. In every such case, as to mechanical and other impurities, analysis will show, and has repeatedly shown, this improper effect. Hence the universal necessity of blowing off at the hydrants, the collections at dead-ends, the complaints common to all supplies, of causes independent of oxidation or other difficulties pertaining to distributing mains, and the knowledge in our houses of storms on the works by our drinking glasses.

But, if this neglect is important as to mechanical impurities, it becomes still more so as to those which are organic. These are at all times objectionable, as infusoria, fungoids, fibrous matter, animalcules, and the like, for human imbibing, but become specially so, when advanced by heat and light to a state of sensible fermentation, which is an effort of nature for self-depuration, and which is probably always at work in insensible degrees in all organic solutions.

If it be answered to this statement, that in warm latitudes the water and the sun have greater tendency to this action than with us, the question of degree may be admitted, but the facts in this case, derived from abundant English testimony, and from that of the supplies of our own country, are formidable in their warnings in this respect. At Boston, New Britain, New York, Brooklyn, Albany, Cincinnati, Pittsburgh, Chicago, Cleveland, Savannah, and other places, the records are unmistakable, and by no means of rare occurrence, and they are witnesses of well known chemical laws, which declare, that as all natural water contains organic matter, it needs watchful protection from its incident affections.

From this process of fermentation, which is frequently observed to be at work far below an inoffensive water surface, and from the plain advantages of æration and surface supply, it is sufficiently evident as to the principle of use, that divisions are of great service in all reservoirs, and should be so arranged as to decant surface currents from one to another in succession, and that the use of a bottom supply is a direct violation of correct principle.

We also learn from evident considerations, that shallow reservoirs, and those of disproportionate storage to supply, are objectionable the moment a reasonable capacity for subsidence is passed. The propriety of covering the floors of reservoirs to prevent vegetation, is also affirmed by numerous examples.

If, then, we do not cover our reservoirs, or use filtering chambers, or if we do, it is essential that their contents should be kept from contact with their earth embankments and flooring, that they should be deep and full, that circulation should be promoted by the use of several divisions, and that their supply should never be taken from the bottom; and no supply is, or can be, independent of great need of these simple and plain precautions, under any temperature.

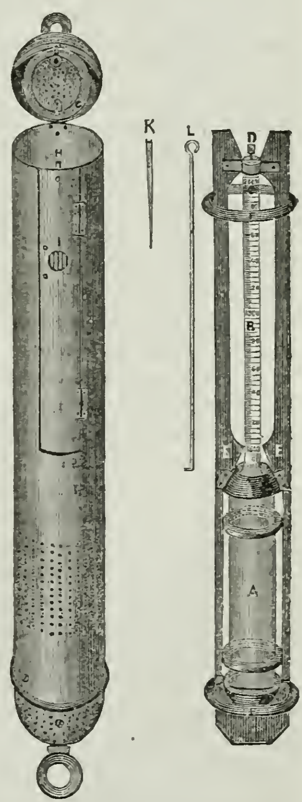
(To be Continued.)

Johnson's Deep-Sea Pressure Gauge.

From the Journal of the Society of Arts, No. 471.

In very deep soundings the pressure of the water is too great to admit of its measurement, except by the use of a body possessing a very slight degree of elasticity.

Mr. Canton, in the year 1761, communicated his observations on the compression of water, which he found to be one part in 21·740, under the pressure of one atmosphere, and in water placed under a receiver, he found an expansion of the same amount, when the air in the receiver was exhausted. Mr. Perkins found a diminution of $\frac{6}{100}$ths of the bulk of water under 1120 atmospheres; that is, about one part in 19,000 for one atmosphere. Water, therefore, possessing this slight degree of elasticity, appears well adapted to determine its pressure at great depths. It is well known that a cork fitted into the neck of a bottle, and lowered in water, will be driven into the body of the bottle if the depth be sufficient; or, if of less depth, that it will be driven down a certain distance, according to the depth to which it is lowered, and that it will as gradually ascend to its original position on being raised to the surface. A gauge made of metal was exhibited last year at the Society of Arts Exhibition of Inventions, and at the meeting of the British Association, reference then being made to the use of glass to vary the experiments, as with metal it is impossible to see when the instrument is free from air bubbles. Mr. Johnson, therefore, had prepared one of glass, which was exhibited by Mr. Glaisher, in Section A, at the last meeting at Manchester.



The instrument now figured is of glass entirely; it consists of a cylindrical glass vessel, with a finely graduated long stem or neck, within which is placed an elastic ring and an elastic stopper; the latter in action pushes the former down the stem, and leaves it at its lowest depression, where it remains acting as an index, whilst the stopper itself again ascends the stem.

In the cut, A is the cylinder; B, stem, with graduated scale; C, flat elastic ring or index; D, elastic stopper; E, metal frame lined with caoutchouc; F, caoutchouc rings, protecting gauge from concussion; G, caoutchouc rings at top and bottom of case, securing the frame in position; H, metal hook on door, securing the top of case; I, clasp to door, let in to avoid pro-

jection; K, "vent" or grooved needle, inserted with stopper; L, brass hook, used to draw up elastic ring.

Some few precautions are necessary to be attended to before use, viz: the vessel must be well rinsed with boiled water, for the purpose of preventing the adhesion of air to its inner surface; next it must be filled with sea-water which has been boiled, and thus freed from air, to exclude all air from the entire vessel and stem.

In this state it is ready for use, and the first step to be taken is to insert the elastic ring and the stopper, with a small grooved needle by its side, thus reserving a small opening for the escape of superfluous water, pressing the stopper so far down the stem, that its lower edge and the first or zero line (marked 2000) on the scale are coincident—then withdraw the grooved needle, and the elastic stopper will tightly fit the stem. To prevent excessive friction of the stopper, it should be slightly lubricated occasionally. On lowering the gauge into water of greater pressure or density than that of the water contained within it, the latter is compressed until it is of the same density as the water by which it is surrounded, and the elastic stopper is pressed down the stem towards the cylinder, at the same time pushing the elastic ring before it. On raising the gauge from water of greater to water of less density, the water contained within the gauge expands, and the elastic stopper is gradually pressed upwards, leaving the elastic ring behind. On arriving at the surface the lower edge of the stopper should be found at zero, and the elastic ring opposite to that division on the graduated stem marking the degree of compression of the water at the greatest depth to which the instrument has been lowered. This depth should be ascertained by the sounding line, to which, at least for some time, the instrument in each experiment should be attached. The mass of water in the cylinder and stem is considered to be divided into 2000 parts, of which the stem contains one-tenth or 200 parts; these are numbered from 1800 to 2000. Each part on the stem may easily be read to a tenth, or 20,000th part of the whole.

A compression of one part in 20,000 is caused by a pressure of 15·8 lbs. avoirdupois, or a depth of sea-water of 35,456 feet, or nearly 6000 fathoms. This result is confirmed both by the experiments of Mr. Canton and Mr. Perkins, and Mr. Johnson, and appears to be a perfectly safe basis for the compilation of tables of comparison and pressure. It is, however, highly desirable that the depths as thus determined, should be compared with those determined at the same time by soundings at different depths, as such would furnish the corrections, if any, necessary to be applied, and give confidence in the indications by the pressure gauge, and enable it to be used with confidence when strong currents render the use of the lead uncertain.

In observation, a small correction will be necessary to be applied on account of variation of temperature, and also for friction; this variation of volume is not uniform, being greater at high than at low temperatures. From many careful experiments made during the past year, it is found that 20,000 parts of boiled sea-water, at 86° Fah., contract to 19,945 at 70°, to 19,899 at 50°, and to 19,880 at 31°.

The following table shows the variation in the volume of sea-water, boiled to free it from air, with change of temperature :—

Thermometer 67·5° Fahr. Barometer, 29·92.

Degrees.	Number of parts.	Degrees.	Number of parts.
Fahr.		Fahr.	
86°	20000·0	53°	19905·0
85	19996·0	52	19903 0
84	19992·5	51	19901·0
83	19989·0	50	19899·0
82	19985 5	49	19897·0
81	19982·0	48	19895 0
80	19978 5	47	19894·0
79	19975·0	46	19892·5
78	19971·5	45	19891 0
77	19968·0	44	19890·0
76	19964·7	43	19889 0
75	19961·5	42	19888 0
74	19958·25	41	19886 7
73	19955 0	40	19885·5
72	19951·5	39	19884 5
71	19948·0	38	19883·5
70	19945·0	37	19883·0
69	19942 5	36	19882·5
68	19940·0	35	19882·0
67	19937·5	34	19881·5
66	19935·0	33	19881·0
65	19932·5	32	19880·5
64	19930 0	31	19880·0
63	19927·5	30	19880·0
62	19925·0	29	19880 0
61	19922·5	28*	19880·0
60	19920·0	27	19880·0
59	19917·5	26	19880·0
58	19915 0	25	19880 0
57	19913·0	24	19880·0
56	199.1·0	23	19880·0
55	19609 0	22	19880·0
54	19907·0		

* A gentle motion kept up to equalize the temperature of the sea-water has prevented its freezing at 28·5°.

Translated for the Journal of the Franklin Institute.

Morin on Resistance of Materials.

At the meeting of the French Academy of Sciences, 10th February, 1862, Gen. Morin made the following remarks :—

In presenting to the Academy this copy of the 3d edition of the work which I have published on the Resistance of Materials, I take the liberty of calling its attention particularly to two questions of considerable importance in this branch of science.

It is known that the fundamental hypothesis of the theory of the resistance of materials to the deformations which exterior forces tend to produce on them, consists in admitting that, within certain limits, determined pretty closely by experiment, the elongations and contrac-

tions experienced by the fibres, are proportional to the strains which produce them, and that within these same limits the fibres return exactly to their primitive dimensions so soon as the causes which have deformed them cease to act. It is then said that the elasticity is not changed.

But within the last few years, Mr. Eaton Hodgkinson, a learned Englishman, to whom we owe a great number of important researches upon these questions, has thought that he could deduce from his experiments that, when a body undergoes any elongation or contraction whatever, it never resumes exactly its former dimensions after the strains have ceased. Consequently, he admits, for example, that in the stretching of a metallic wire, there is always produced, in addition to the elastic elongation which ceases with the traction, a permanent elongation.

The discussion of the experiments of Mr. Hodgkinson, the examination of the arrangements which he had made for their execution, and the exceeding smallness of the permanent elongations observed, had led me to attribute these elongations, not to a deformation or variation in the length of the fibres themselves, but to a packing of the points of bearing and juncture, and the general straightening of the pieces under trial. This explanation appeared more probable to me, since the bars, of 15 metres total length, employed by Mr. Hodgkinson were made up of several pieces united by screws whose threads were in opposite directions, which under the action of the loads might well undergo packing.

To relieve the doubts upon this subject, it appeared to me necessary to make especial experiments, operating on metallic wires of a great length and of a single piece. For the execution of these experiments, I took advantage of the great height of the experiment-gallery of the *Conservatoire des Arts et Metiers*, and I could thus submit to traction copper and iron wires of over 22 to 24 metres in length.

By means of very precise cathetometers, the elongations produced between two marks traced on the wires, 21 metres apart, could be observed to a hundredth of a millimetre.

These experiments, however, presented a difficulty arising from the fact that the wires employed could only be found in commerce in the form of rolls of from 0·6 met. to 0·7 met. diameter, and that it was very difficult to straighten them completely before the experiment; so that they still presented slight bends, called *cosses* (kinks), the successive straightening of which under the action of the strains might and did exercise a certain influence on the results. But by repeating the experiments several times, this effect once produced ought to become less and less, and the true process of stretching ought to show itself better and better.

The weights suspended from the wires being added and removed successively, we could observe the elongation due to each one, and the return to the primitive length when they were removed, whence the values of the elastic and permanent elongations were deduced.

Now, while within extensive limits the first remained proportional

to the weights, as the theory requires; the others, which were always very small, went on diminishing from one experiment to another, in proportion as the wires were more completely straightened.

Thus, two copper wires, tried successively, gave the following results for the permanent elongation, measured in the fraction of the primitive length:—

No. 1. Diameter 2·584 mm., $\frac{1}{29,585}$, $\frac{1}{116,661}$, $\frac{1}{285,715}$;

No. 2. " 2·6 " $\frac{1}{15,000}$, 0, $\frac{1}{112,903}$;

quantities which may evidently be neglected when compared with the influence of the slightest change of temperature, since according to the results of La Place and Lavoisier, a difference of a single degree of the centigrade thermometer produces a change of length of $\frac{1}{58,400}$.

This last observation, indeed, explains how in the second experiment on wire No. 2, the permanent elongation might be 0, in consequence of a slight lowering of the temperature.

The examination of the co-efficient of elasticity deduced from these experiments, moreover, proves that in none of them was the elasticity changed. These co-efficients have the following values:—

No. 1. 6,909,971,309 kil.; 7,118,354,507 kil.; 6,521,770,186 kil.;
Mean, 6,850,003,001 kil.

No. 2. 7,310,170,535 kil.; 8,777,809,696 kil.; 7,374,366,197 kil.;
Mean, 7,827,448,809 kil.

General mean, 7,338,740,408 kil.

It will be observed that these values are all lower than those given by old experiments, which are for—

Drawn copper wire,	12,000,000,000 kil.
Annealed do.,	10,500,000,000 kil.
Mean,	11,250,000,000 kil.

It is, moreover, proper to observe that the densities of the wires anciently experimented on are greater than those of the wires now found in commerce, and that it appears to result from the comparison of the results of the old and new experiments, that, for the same metal, the elasticities vary in the same ratio with the density; which, moreover, appears rational.

Analogous experiments were performed on very fine iron wires of 0·2 mm. diameter; and by repeating the experiments three times in succession, the permanent elongations were found to be

$$\frac{1}{29,762}, \frac{1}{277,777}, \frac{1}{312,500},$$

whilst the elastic elongations remained very nearly the same, the co-

efficient of elasticity having the following values:—

19,326,210,980 kil.; 19,747,235,387 kil.; 19,857,029,388 kil.;
Mean, 19,643,458,585 kil.;

a value which differs very little from that deduced from the flexion of the best iron.

From the whole of these experiments, as well as from all those which I have had executed upon the flexion of bars of very great dimensions of cast iron, wrought iron, and steel, the proof appears to me to result, that the elongations and contractions pointed out by Mr. Hodgkinson could only be the effect of the packing, the partial compression of the junctures, or of the supports of the apparatus which he employed, and that the fundamental hypothesis of the theory of the resistance of materials, announced for the first time by the celebrated Hooke in 1670, in these terms, *ut tensio sic vis,* is in accordance with observation.

Another chapter to which I think it useful to call the attention of the Academy, is that which treats of axles and the tests to which they are subjected. By the discussion of these tests, and by the comparison of their results with the gradual variation of the co-efficient of elasticity in function of the elongations, I show that, in the regulation tests, the strains upon those fibres which have undergone the greatest elongations do not attain to the limit of rupture. On the other hand, I show by direct experiments that the straightening of axles which have been bent in these tests does not sensibly change their elasticity, provided it be properly done.

The general conclusions of this chapter are:—

1st, That the tests adopted by the artillery and the railroad companies, may, without danger of alteration, be undergone by good irons.

2d, That they separate the medium or bad irons.

3d, That, to compare them together, it is sufficient to limit the flexions so that the greatest elongations of the fibres shall be the same for all the axles.—*Comptes-Rendus,* 10 Feb., 1862.

Testing Armor Plates.

From the London Artizan, March, 1862.

The testing of the armor plates from the works of the Thames Iron Ship Company, the Atlas, at Sheffield; and the Lancefield, at Glasgow; were brought to a conclusion on the 14th ult. The plates as usual, were affixed to the sides of the *Java,* and the practice took place from the guns of the *Stork,* at 200 yards range. They were plates selected by the Government Inspector at each of the works from those manufactured in accordance with the right reserved by the Admiralty in their contract with the manufacturers. At this trial the "hammered plates" supplied by the Thames Iron Ship Building Co. proved to be so superior, that it will in all probability be the cause of the re-opening of the question, "Hammered *v.* Rolled" armor plates. 100-pounder Armstrong guns were used for the trial. The order of merit was as follows: Thames, 1; Brown, Rigby & Beardmore, 3.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Experiments on Illumination with Mineral Oils.

By James C. Booth and Thos. H. Garrett.

On account of the abundant supply of petroleum or mineral oil, and its increasing consumption for illumination, we were induced to make some experiments in a practical way, for determining its illuminating power and economic value.

As in all such experiments, we also found the lack of a reliable standard of comparison, but as our object was purely practical, we employed Philadelphia city gas as our standard, because of its convenience, the tolerable accuracy of its measurement, and its sufficient uniformity of composition through the time required for each series of experiments. We measured the gas by a water-meter made for nice measurements, and which was kindly loaned to us by Dr. Charles M. Cresson. The gas-jet, a good fish-tail burner, was attached to the top of the meter, and was fixed at the uniform distance of six feet from the photometer. The distance of the lamp, &c., giving equal light to the gas-jet, was measured on the opposite side of the photometer. We may mention once for all, that, except in two cases expressly stated, all the flames were raised to their fullest height, just below the point of smoking.

We first ascertained that the results of experiments at a different flow of gas were not reducible to those of a uniform flow with any degree of accuracy with the burner we employed, and without a regulator, as indeed we might have concluded without experiment. The following table shows this:—

Table I.

No. of the experiment.		Flow of gas in cubic feet per hour.	Intensity of gas. / Intensity of lamp = 1.	Intensity of 2 and 3 calculated from 5·3 to 5 6 and 4·1.	Intensity of 2 and 3 calculated to that of 5·3 from the observed intensities at 5·6 and 4·1.
Lamp A.	1	5 3	1 5410	1·5410	1·5410
	2	5·6	1·6531	1 6283	1·5645
	3	4·1	1·3486	1·1650	1·7433
Lamp B.	1	5·3	1·8455	1·8455	1·8455
	2	5·6	2·0736	1·9848	1·9281
	3	4·1	1·6239	1·4277	2 0992

Although we found that, where the flow of gas differs only by ·1 or ·2 cub. ft. per hour, the calculated intensity approached to that deter-

mined by experiment, yet we concluded to present only the results of observation, as better for practical purposes.

We first determined the relative economy of several coal and mineral oils, and of burning fluid, at the request of Mr. Horace J. Smith, with the following results. The gas was flowing at the rate of 5·3 cub. feet per hour. The oils were burned in the same kind of lamps as in the subsequent experiments, and the burning fluid in the ordinary lamp used for it, with two divergent cylindrical wicks.

TABLE II.

NAME OF OIL.	Intensity of lamp. Gas = 1.	Gallons burned during flow of 1000 cub. ft. of gas.	Gallons giving equal light to 1000 cub. ft. of gas.	Relative amount burned. Best = 100.	Specific gravity of oil at 68° F.
Natrona, .	·6274	1·545	2·463	100	·7935
Portland, .	·6158	1·558	2 529	103	·8077
Lucifer, .	·6158	1·595	2·590	105	·7918
Lucesco, .	·5935	1·670	2·813	114	·7940
Burning fluid,	·1554	1·819	11·699	475	

As experiment thus proved that there was no great difference between the mineral oils, we selected one of them, "Lucifer Oil," and employed it in all subsequent experiments. In most of these, the common coal-oil lamp was used, with a flat wick of 0·7 inch breadth, by 0·08 inch thickness, and a hemispherical cap or deflector, with a lune or very elongated oval slit, through which the flame issues.

We ascertained that a perfectly straight cut of the wick yielded tolerably uniform results, differing but a few per cent. in relative economy, as the following shows:—

TABLE III.

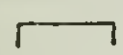
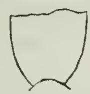
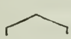
No. of experiment.	Intensity. Gas = 1.	Gallons of oil burned giving equal light to 1000 cub. ft. of gas.	Relative amount for equal light.
1	·61579	2·78	100
2	·61579	2 80	101

These results were obtained at the same time with two lamps, but at different times and pressures of gas, they show an extreme variation that may amount to 15 per cent., chiefly due to the variation in our standard, burned from the same jet, at different pressures.

We then determined the influence of the shape of the top of the wick to ascertain the relative economy of care or carelessness in trimming the wick, with the following results. The 1st column in table IV. states the number of the experiment; the 2d gives the trim of the top of the wick; the 3d the shape of the flame; the 4th the in-

tensity of the light, compared to gas as unity; the 5th gallons of oil consumed during the flow of 1000 cub. ft. of gas, at the rate of 5·4 cub. ft. per hour; the 6th the gallons of oil that would be consumed to produce an equal light with 1000 cub. ft. of gas at the same rate of flow; the 7th the relative amount consumed for equal light, assuming the best at 100.

Table IV.

1.	2.	3.	4.	5.	6.	7.
No. of experiment.	Trim of wick.	Shape of flame.	Intensity of light of oil. Gas = 1·0.	Gallons of oil burned during flow of 1000 cub. ft. of gas.	Gallons of oil giving equal light to 1000 cub. ft. of gas.	Relative amount consumed for equal light.
1			·6267	1·614	2·576	100·0
2			·4727	1·345	2·846	110·5
3			·3906	1·125	2·880	111·8
4			·4259	1·247	2·929	113·7
5			·4171	1·223	2 932	113·8
6			·4082	1·199	2·936	114 0
7			·3735	1·150	3·078	119·5

A simple inspection of the 7th column shows that by any other method of trimming the wick than by a straight cut, No. 1, there is a loss of oil to obtain an equal amount of light, and that this loss may amount to from 10 to 20 per cent., where the wick is very badly

trimmed. The trim of wick was much exaggerated over what is likely to occur in practice, as shown in the 2d column, but in another experiment, in which the salient and retiring angles, as Nos. 3 and 7, were much more obtuse, the loss amounted to 4 per cent. in a trim like No. 3, and to 7½ per cent. in one like No. 7. In all our trials, the straight trim, No. 1, proved most economical, and that with a re-entering angle, No. 7, the worst. In giving a straight cut, threads of the woof are apt to project above the cut, or loose threads are allowed to remain on the wick. Their influence is shown in Nos. 5 and 6, and they may occasion a loss as high as 14 per cent. It frequently happens that in giving a straight trim, the two corners are apt to be left jagged, and to produce pointed and wasteful flames. We then tried the influence of cutting off these corners by a slight oblique cut after trimming straight. The loss was only 5 or 6 per cent., although our trim was much exaggerated. The best method of obtaining the fullest amount of light is to trim the wick straight across, and test the shape of the flame by lighting the lamp temporarily, and then, if necessary, to retrim it until the shape approaches that of No. 1, presenting as even a top as practicable.

We determined the relative economy of a full and two-thirds sized flame in the same lamp, and that of two smaller lamps, with the results in table V. The columns are numbered, as in table IV., the trim of wick and shape of flame, columns 2 and 3, being omitted. In experiments 1 and 2, the same lamp was employed as before. In experiment 3, a similar but smaller sized lamp was used, with a wick 0·4 inch broad by 0·08 inch thick. In experiment 4, a small chamber lamp was used, with a cylindrical wick 0·15 inch diameter (like that of a common oil lamp), and a flat horizontal deflector, with a circular hole through which the flame issues. This flame is a very elongated cone of nearly 1½ inches height at its fullest without smoking, and ⅛ inch diameter. The flow of gas was 5·1 cub. ft. per hour.

Table V.

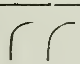
1.	4.	5.	6.	7.	
No. of experiment.	Intensity of light of oil. Gas = 1.	Gallons of oil burned during flow of 1000 cub. ft. of gas.	Gallons of oil giving equal light with 1000 cub. ft. of gas.	Relative amount burned for equal light.	Remarks.
1	·6158	1·709	2·776	100	Large lamp, full flame.
2	·4444	1·278	2·875	103	do. ⅔ full flame.
3	·3735	1·071	2 867	103	Smaller lamp, full flame.
4	·0772	0·345	4·475	161	Chamber lamp, full flame.

There appears to be little waste (only 3 per cent. for equal light) in burning a lamp at ⅔ the fullest height of the flame (compare Nos. 1 and 2); nor is there much difference (3 per cent.) between the larger

and smaller lamps, Nos. 1 and 4. Of course the chamber lamp, experiment 4, is not designed to give much light, and hence it appears to lose 60 per cent. in economy to obtain an equal amount of light from it. Its true economy consists in the very small quantity of oil consumed by it, with sufficient light for the purpose for which it is used, during the flow of 1000 cub. ft. of gas (at the rate of 5·1 cub. ft.), which is only one-third of a gallon. We shall revert to relative cost further on.

While making these experiments on the oils, we concluded to extend them a little further, in order to make a comparison of the oils with several kinds of candles in common use. The results are given in table VI., in which columns 1, 2, 4, 5, 6, and 7, correspond to the same of tables IV. and V., except that pounds a. d. p. are used instead of gallons (column 3, shape of flame, is omitted). Two candles were employed each experiment, but the results in columns 4 and 5 are reduced to the effect of one candle. This of course does not affect the quantities for equal light in columns 6 and 7. Paraffine candles were employed in experiments 1 and 2, spermaceti in 3 and 4, and adamantine in 5. In experiments 1, 3, and 5, the wicks were arranged so as to burn the material to the best advantage, but in 2 one of the paraffine wicks, and in 4 both of the sperm wicks, were only slightly curved, and had small beads of snuff on their tips, as shown in column 2. The rate of gas is 5·1 cub. ft. per hour.

TABLE VI.

1.	2.	4.	5.	6.	7.
No. of experiment.	Shape of wick.	Intensity of one candle. Gas = 1.	lbs. of candles burned during flow of 1000 cub. ft. of gas.	lbs. of candles giving equal light to 1000 cub. ft. of gas.	Relative amount burned for equal light.
1		·1019	3 507	31·42	100
2		·0957	3·507	36 64	106
3		·1050	3·912	37·25	108
4		·0868	3·912	45·07	131
5		·1080	5·098	47 18	137

A comparison of the results in column 7, compared with the shape of wicks in column 2, shows the importance of not permitting beads of snuff to accumulate on the ends of the wick. To obviate it, it is only necessary to keep the wick bent nearly at right angles, as shown

in experiments 1, 3, and 5, in column 2, so that the air will keep the wick *snuffed*, by burning off the extremity.

It is hardly fair to compare candles and gas for equal light, as in column 6 of table VI., because the former are rarely employed for illuminating a large space, to which gas is peculiarly well adapted. If we compare the result of two candles, which give a fair amount of light for reading and work near them, we have only to double the figures given in col. 4 for intensity, and in col. 5 for the quantity used in the same time as 1000 cub. ft. of gas flowing at the rate of 5·1 cub. ft. per hour. This quantity would be 7 lbs. for paraffine, 7¾ lbs. for spermaceti, and 10 lbs. for adamantine candles.

If we now make a comparison of the relative cost of gas and mineral oils, we shall first suppose them employed for illuminating a large space. In this case, we can only compare them with reference to an equal amount of light. When burning to fair advantage, it appears from table III., experiments 1 to 4, and tables IV. and V., experiment 1, that 2½ to 2¾ gallons of oil give equal light with 1000 cub. ft. of gas. To these we will add by way of contrast, the best results with candles in table VI., experiments 1, 3, and 5. We have added a column for cost of 1000 cub. ft. of gas, of one gallon of oil, and of a pound of candles, and finally the column of expense for equal light.

Table VII.

Name of Material.	Quantity for an equal amount of light.	Price of unit of quantity.	Cost of quantity for equal light.
Gas, . .	1000 cub. ft.	$2 25 per 1000 C.F.	$2 25
Petroleum,	2⅜ galls.	0·45 " gall.	1 07
Candles. Spermaceti, .	37 lbs.	0·50 " lb.	18·50
Candles. Paraffine,	36½ "	0·32 "	11·68
Candles. Adamantine,	47 "	0·25 "	11·75

It will be observed that we have taken fair retail prices. It is hardly worth while to call attention to the extravagance of employing candles for illumination. It is more to our purpose to compare gas and mineral oil. Even allowing the price of gas to be reduced, we find that it costs twice as much as mineral oils for producing equal light. A moment's consideration, however, will show that, for all ordinary uses, the comparison for an equal amount of light is an unfair one for the oil. Gas-lights are fixed, or at best can be moved by a swing-joint or drop-light within a very limited space; so that any work to be done must, however inconvenient, either be carried near to the jet, or we must employ a larger amount of gas, proportioned to the *square* of the distance, *i. e.*, at twice a given distance, four times as much gas is required for an equal effect, &c. On the other hand, the lamp can be moved to any position most convenient for work, with this increased benefit, that the intensity of its light is inversely as the square of the distance.

It is because of the fixedness of gas-light, and the movability of the

lamp, that so much less of the oil is required to obtain an equal advantage of light, and the amount of oil burned in the common coal oil lamp, as employed in our experiments, in the *same time* as 1000 cub. ft., expresses more correctly their relative economy. As two candles are usually burned for the same purpose, we insert their results also in the following table. Further, as the smaller lamp, table V., experiment 3, is considered as affording ample light by many persons for reading, sewing, &c., we have included it. Lastly, the small chamber lamp, table V., experiment 4, is included so that persons may compare its cost with that of the wax taper floating on oil, or any other night-light. In order to make a fairer comparison of cost, the price of gas is assumed at \$2·10 per 1000 cub. ft.

TABLE VIII.

Name of Material burned.	Material—how burned.	Quantity burned in same time as 1000 cub. ft. of gas.	Relative cost of material burning in equal time.	Cost for an average winter evening of 5 hours.
Philada. Gas,	5·1 cub. ft. pr hour.	1000 cub. ft.	\$2·10	$5\frac{1}{3}$ cents.
Petroleum,	Large lamp.	$1\frac{5}{8}$ galls.	0·73	$1\frac{7}{8}$ "
do.,	Smaller do.	1 "	0·45	1 1-7 "
do.,	Chamber do.	$\frac{1}{3}$ "	0·15	$\frac{3}{8}$ "
Spermaceti,	Two candles.	$7\frac{3}{4}$ lbs.	3·87	$9\frac{7}{8}$ "
Paraffine,	do.	7 "	2·24	5·7 "
Adamantine,	do.	10 "	2·25	$5\frac{3}{4}$ "

A small chamber-lamp is usually burned through the whole night, say for 10 hours. In this case it costs three-fourths of a cent per night. But let it be observed that at this rate of cost it gives three-fourths as much light as a sperm, paraffine, or adamantine candle, as shown by comparing its intensity, No. 4, table V., with those of experiments 1, 3, and 5, table VI. To ascertain the lowest limit of cost of this little lamp, we tried its consumption of oil with a very low flame, rising about one-tenth of an inch above the deflector, its light (not measured) appearing to be somewhat less than that of the common night taper. In this case, its expense would be a little more than one-fourth of a cent for ten hours. But, at this low limit, combustion is not perfect, and a disagreeable odor arises from it. When burned at $\frac{1}{3}$ to $\frac{1}{2}$ its fullest height, it emits no odor, and then costs a little more than one-third of a cent for ten hours.

In this essay we have only taken into consideration the relative economy of mineral oils as sources of light, compared with gas and candles, in which respect the last column in table VII., and especially the 4th column in table VIII., show most convincingly that the oils will force themselves more and more into notice and use, and to a moderate extent will displace the use of gas and candles.

It would, however, be a partial and, perhaps, culpable view of the subject, if we were to omit a notice of danger in the use of the mineral oils, whether obtained from coal or petroleum. We have not made any direct experiments on this point, but we are bound to admit the

result of experience in the use of the oils. Although they are far less explosive than burning fluid, or any alcoholic solution of a hydro-carbon, they are by no means free from liability to explosion. The danger arises from the presence of benzole (benzine), and other volatile hydro-carbons, which have not been expelled in the process of refining, and we shall probably be subjected to this danger some time longer, in consequence of the want of skill which knows not how to remove the volatile fluids, or by reason of manufacturing cupidity, which would prefer allowing them to remain in the oil, in order to increase the quantity sold. We think there is ground for asserting that the mineral oils *can be made* as free from danger as spermaceti or lard oil. One great desideratum is a means of determining the freedom from danger by a simple apparatus, easily and inexpensively worked. Until the character of large dealers shall have been established for the sale of oil free from danger, we will content ourselves with this general advice to those who use the oils: never to fill a lamp at night, and not to store the oil where it can become heated.

It is not to be apprehended in the slightest degree that the oils will supersede the use of gas, especially in cities and towns, nor even in many country houses. Saving of labor, convenience, and greater safety, will cause gas still to dominate over all other sources of illumination. Besides, the astonishing cheapness of the natural mineral oils, and their richness in illuminating hydro-carbons, will probably oblige gas companies to consider the advisability of mixing mineral oil gas with coal gas. The illuminating power of any coal gas we have seen may be greatly increased with advantage, and the consequent liability to smoke may be obviated by diminishing the size or improving the form of the jet or burner.

Would the growl of the public be heard against a change of burners if they were to receive due notice that on and after a certain date, if they were to change all their burners to one-half the present size, they would get the same amount of light as they now do, without any more smoke, and at one-half the present cost? especially when they are informed that the whole cost of the change will be defrayed by the saving of the first six months or a year? We leave it to gas companies to resolve this question or its alternative, whether the extraordinary comparative cheapness of mineral oil illumination will not stimulate invention to contrive ways of burning the oil, or of making gas from it in a small way, so as to obviate every objection to its use, and so to supersede the use of company-made gas.

Letter from Prof. KIRCHHOFF *on the Chemical Analysis of the Solar Atmosphere.*

From the Lond. Edin. and Dub. Phil. Mag., March, 1861.

Since I sent in my last report to the Berlin Academy, I have been almost uninterruptedly engaged in following out the investigation in the direction I there indicated. I will not now speak either of the

theoretical proof I have given,* of the facts I there announced, or of the experiments by help of which Bunsen and I† have shown that the bright bands in the spectrum of a flame serve as the surest indications of the metals present therein; I will take the liberty, in this communication, of informing you of the progress I have made in the chemical analysis of the solar atmosphere.

The sun possesses an incandescent, gaseous atmosphere, which surrounds a solid nucleus having a still higher temperature. If we could see the spectrum of the solar atmosphere, we should see in it the bright bands characteristic of the metals contained in the atmosphere, and from the presence of these lines should infer that of these various metals. The more intense luminosity of the sun's solid body, however, does not permit the spectrum of its atmosphere to appear; it *reverses* it, according to the proposition I have announced; so that, instead of the bright lines which the spectrum of the atmosphere by itself would show, dark lines are produced. Thus we do not see the spectrum of the solar atmosphere, but we see a negative image of it. This, however, serves equally well to determine with certainty the presence of those metals which occur in the sun's atmosphere. For this purpose, we only require to possess an accurate knowledge of the solar spectrum, and of the spectra of the various metals.

I have been fortunate enough to obtain possession of an apparatus from the optical and astronomical manufactory of Steinheil in Munich, which enables me to examine these spectra with a degree of accuracy and purity which has certainly never before been reached. The main part of the instrument consists of four large flint-glass prisms, and two telescopes of the most consummate workmanship. By their aid, the solar spectrum is seen to contain thousands of lines; but they differ so remarkably in breadth and tone, and the variety of their grouping is so great, that no difficulty is experienced in recognising and remembering the various details. I intend to make a map of the sun's spectrum as I see it in my instrument, and I have already accompanied this for the brightest portion of the spectrum—that portion, namely, included between Fraunhofer's lines F and D. By painting the lines of various degrees of shade and of breadth, I have succeeded in producing a drawing which represents the solar spectrum so closely, that, on comparison, one glance suffices to show the corresponding lines.

The apparatus shows the spectrum of an artificial source of light, provided it possess sufficient intensity, with as great a degree of accuracy as the solar spectrum. A common colorless gas-flame in which a metallic salt volatilizes, is in general not sufficiently luminous; but the electric spark gives with great splendor the spectrum of the metal of which the electrodes are composed. A large Ruhmkorff's induction apparatus produces such a rapid succession of sparks, that the spectra of the metals may be thus examined with as great facility as the solar spectrum.

By means of a very simple arrangement, the spectra of two sources

* Phil. Mag., July, 1860. † Ibid. August, 1860.

of light may be compared. The rays from one source of light can be led through *one* half of the vertical slit, whilst those from another source are led through the *other* half. If this is done, the two spectra are seen directly under one another, separated only by an almost invisible dark line. By this arrangement, it is extremely easy to see whether any coincident lines occur in the two spectra.

I have in this way assured myself that all the bright lines characteristic of iron correspond to dark lines in the solar spectrum. In that portion of the solar spectrum which I have examined (between the lines D and F), I have had occasion to remark about seventy particularly brilliant lines as caused by the presence of iron in the solar atmosphere. Angström only observed three bright lines in this part of the spectrum of the electric spark; Masson noticed only a few more; Van der Willigen says that iron produces only a very few feeble lines in the spectrum of the electric spark. From the number of these lines which I have been able to observe with ease and map with absolute certainty, some idea may be formed of the capabilities of the instrument which I am fortunate enough to possess.

Iron is remarkable on account of the number of the lines which it causes in the solar spectrum; magnesium is interesting because it produces the group of Fraunhofer's lines which are most readily seen in the sun's spectrum, namely, the group in the green, consisting of three very intense lines, to which Fraunhofer gave the name *b*. Less striking but still quite distinctly visible are the dark solar lines coincident with the bright lines of chromium and nickel. The occurrence of *these* substances in the sun may therefore be regarded as certain. Many metals, however, appear to be absent; for although silver, copper, zinc, aluminium, cobalt, and antimony, possess very characteristic spectra, still these do not coincide with any (or at least with any distinct) dark lines of the solar spectrum. I hope before long to be in a position to publish more extended information on this point.

The combination of Ruhmkorff's induction coil with the spectrum apparatus will doubtless also be of importance for the chemistry of terrestrial matter. Very many metallic compounds do not give the spectrum peculiar to the metal when placed in a flame, because they are not sufficiently volatile, but they give it at once when placed on the electrodes of an electric spark. These lines are then indeed seen, together with those of the metal of the electrode, and those of the air through which the spark passes; and owing to the great number of bright lines which compose the spectrum of every electric spark, it would be almost impossible, without a special arrangement, to distinguish the lines caused by the metal of the electrodes from those produced by the metallic salt added. The special arrangement which in this case removes all difficulty, consists in allowing the spark to pass at the same instant between two pairs of electrodes, in such a manner that the light of one spark passes through the upper half of the slit, whilst the light of the other spark passes through the lower half of the slit, so that the two spectra are seen one directly above the other. If both pair of electrodes are pure, both the spectra are

alike; if a metallic salt is brought on to one of the electrodes, the lines peculiar to that metal appear in the one spectrum in addition to those present before. These are recognised at the first moment, because they are absent in the other spectrum. The lines which are common to the two spectra may serve, when they are once for all drawn, as the simplest mode by which to represent the position of the lines of the other metals employed.

I have proved that in this way the metals of the rare earths, yttrium, erbium, terbium, &c., may be detected in the most certain and expeditious manner. Hence we may expect that, by help of Ruhmkorff's coil, the spectrum-analytical method may be extended to the detection of the presence of all the metals. I trust that this expectation may be borne out in the continuation of the research which Bunsen and I are jointly carrying on with the object of rendering this method practically applicable.

Waterproof Glue.

From the Lond. Chemical News, No. 41.

Fine shreds of india rubber, dissolved in warm copal varnish, make a waterproof cement for wood and leather. Take glue, 12 ounces, and water sufficient to dissolve it; then add 3 ounces of resin, and melt them together, after which add 4 parts of turpentine. This should be done in a water bath, or in a carpenter's glue-pot. This also makes a very good waterproof glue.

Lock Controversy.

From the Journal of the Society of Arts, No. 476.

Steps are being taken in Wolverhampton which are likely to revive the great lock controversy of ten years ago. There is now in course of manufacture in that town a new patent keyless lock, having 244,140,125 combinations, to open all of which would take a man—supposing he could live so long—some 130 years! This extraordinary lock, which is based upon the permutation principle, is the invention of Viscount de Kersolon, of Paris, and by him communicated to Mr. Edward Loysel, of Cannon street, London, who is better known as the patentee of the coffee percolator. Although it is termed a keyless lock, it has as many keys as there are combinations, the back parts being the locks, and the front parts the keys, which cannot be removed. Every change made in the concentric rings answers the same purpose as the keys, so that a lock which has seven permutations, or 5040 combinations, has 5040 keys, and so it is termed a keyless lock, with 5040 or any number of keys. The specimen has six concentric cylinders, upon the projecting or outer edges of which are twenty-five of the twenty-six letters of the alphabet, and it is only when these letters are brought into a certain predetermined arrangement that the other parts of the lock can be so worked as to admit of the bolt being

drawn for the purpose of shutting or opening the article to which the lock is applied. It is absolutely necessary, as in the old letter padlock, to know the proper arrangement or combination of letters before the lock can be opened. In order to prevent the particular combination of letters from being discovered by feeling the parts, as is sometimes the case, the inner edges of the movable concentric cylinders are toothed or serrated, so as to deceive any person who may attempt to tamper with the lock. In the event of the particular combination of letters not being discovered by the person desirous of opening the lock, the exhausting of all the variations which are in that case necessary to the success of the operation would entail an expenditure of the time we have mentioned, supposing the operator to make ten changes a minute, and to manipulate ten hours on every working day. It is intended to place these locks on some iron safes which are also being made in Wolverhampton for exhibition at the forthcoming "World's Fair." In one of the safes it is proposed to place the sum of £500, which is to fall to the lot of the person who may be fortunate enough to effect an opening into the safe.

The production of the lock for the market is in the hands of Mr. Aubin, the inventor of the "Trophy lock of ingenuity," which was exhibited in the Hyde Park Palace, and subsequently purchased by Mr. Hobbs. Mr. Aubin, then a working locksmith, is now the proprietor of works in Wolverhampton, where he employs machinery invented by himself, and of equal delicacy with that displayed in the model which made his name celebrated. His ingenuity is being further displayed in the designing and constructing of machinery adapted to the manufacture just described. Mr. Aubin's practical experience also is being brought to bear in making such improvements upon the Count's lock as are required to increase the probability of its success in a financial aspect. The principle of the lock may be applied to every variety of this description of fastening, and when used upon a traveling bag is a vast improvement upon locks that require keys to open them, and is at the same time a great ornament.

New Substitute for Silver.

M. Traluc, of Nismes, has recently proposed as a substitute for silver for various uses, a white alloy which has the property of resisting vegetable acids. It is formed of 375 parts of Banca tin; 55 nickel; 50 regulus of antimony; 20 bismuth. One-third of the tin is put in a crucible of the proper dimensions with the nickel, antimony, and bismuth; upon this first layer is put another third of the tin, and then a thickness of an inch and a half of wood-charcoal; the crucible is then to be covered and brought to a white-heat; by means of an iron rod also heated to redness it must be ascertained that the nickel is fused, and the antimony reduced; the remainder of the tin is then introduced through the charcoal, and the mass stirred until the metals are thoroughly combined; it may then be cast in ingots or otherwise.

Cosmos.

On the Construction of Iron Ships of Great Length. By WILLIAM FAIRBAIRN, Esq., LL.D., F.R.S., &c.

From the London Mechanics' Magazine, November, 1860.

In a previous lecture I endeavored to inculcate principles on which iron ships ought to be built, in order to secure perfect safety, and to give to the public increased confidence in the stability of these constructions. In pointing out how these desiderata may be obtained, I confined my attention to vessels varying from 500 to 1500 tons burthen, and not exceeding 300 feet in length and 41 feet 6 inches beam. In these constructions I attempted to prove that the present system was defective, and that in certain positions a vessel built upon this principle must, of necessity, break up and go to pieces. These views were not founded upon theoretical speculations, but upon experimental facts; and to which I considered it my duty to direct public attention.

It cannot be denied that the most disastrous effects have followed from these defects; and it appears imperative, for the sake of life and property, that a new and more perfect system of construction should be adopted, founded on definite laws by which the resisting powers of materials in different forms and conditions are governed. As respects iron, nearly the whole of these laws are known; and we are at no loss to discover its ultimate powers of resistance in whatever position it is placed, or to proportion its dimensions to meet with safety the forces to which it is subjected. Possessing this knowledge, and having it in our power to apply it, why should we neglect its application in structures of such vast importance as those in which our lives and fortunes are so often embarked? The surveyors of Lloyds, most excellent, well meaning, gentlemanly men as they are, may say what they please; but I have no hesitation in stating that their regulations are very defective and require immediate revision, and such a revision in my opinion should be based upon principles of exact science, and calculated to secure a maximum strength in the iron ship. I do not wish to find fault, nor do I assert that the alterations I have to propose are in any sense the best calculated to produce a maximum effect; on the contrary, they may require correction in practical details. But this I believe, that the present build of ships is decidedly imperfect, and admits of great improvement, both as regards security and economy in the use of the material of which they are composed.

The cellular system has been objected to on the ground of the inconvenience of longitudinal stringers along the deck on each side of the hatchways, and their liability to oxidation. Now, so far as regards the deck, these objections have in reality no weight, for the proposed cellular stringers need not exceed fifteen inches square, or eighteen inches wide by fifteen deep; and these, with the cells which form part of the bulwarks, will afford all that is wanted to give the required stability to that part, forming, if properly put together, perfectly rigid horizontal columns to resist the force of compression on the one hand, and tension on the other. Again, as regards oxidation, none can occur to any injurious extent so long as these cellular stringers are below deck and are riveted water-tight, which may be done with perfect

safety and without diminution of their strength. From these remarks, and from previous statements, it will be seen that the excess of material is not required in the vicinity of the neutral axis, where the strain is least, but at the extreme top and bottom, where the strains are most severe when the vessel is pitching in a heavy sea.

It is a universal law of construction that the resistance provided for should be proportional to the assailant force in each part, and in order to effect security it should be always greatly in excess. In building a ship, as in other similar structures, the first thing is to ascertain the points of greatest strain, and to provide at those parts the greatest power of resistance; but to build a ship with equal thicknesses of plates throughout, or any other vessel liable to be ruptured by forces that act with double the intensity in some parts that they do in others, is not only a great waste of valuable material, but is absolutely injurious in so far as it adds by increased weight to the destructive element that tends to break up the vessel. This being the case, how essentially necessary is it that the strengths should be carefully proportioned to the strains, and the material arranged in such a form as to offer a harmonious resistance to the forces thus acting upon it.

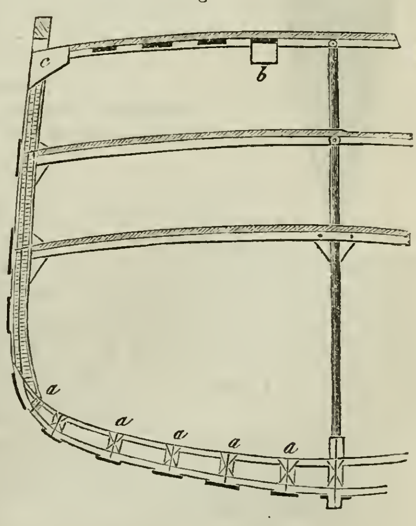
To effect this distribution, the object of the previous investigation, and keeping in view the same principles I there ventured to advocate, I now come to a larger class of vessels, which involve at the present time considerations of vast importance to the owners and builders and others interested in the extension of commerce. To these vessels I would now venture to apply the same principles, so as, in my opinion, to secure the necessary strength under the varied forms and circumstances to which they are subjected.

We do not know what changes are in store for us as a result of the performance of the Great Eastern; that vessel has not yet been fully tried, and it would be premature to anticipate results; as it is, we can only assume that she will prove commercially successful, and although probably not to the extent expected by her more sanguine advocates, yet that she may possess qualities favorable to a considerable increase in the dimensions of our vessels, both in relation to their capacity for cargo, speed, and other good properties. If we assume this as the result of the forthcoming performances of the Great Eastern, we may take as the basis of our inquiry a vessel of 500 feet length between the perpendiculars and 68 feet beam. The question for consideration then is, on what principle should she be built for the purpose of attaining the greatest security with the least material? To answer this inquiry we may consider—

1. The general principle of construction.
2. The frames and ribs, and their distribution as affecting the transverse strength.
3. The plating or sheathing, including stringers, cells, &c., as affecting the longitudinal resistance to fracture.
4. The decks, bulkheads, and internal fittings.
5. The bows and stern in their resistance to concussion.
6. The resisting powers, durability, and economy of the ship taken *en masse*.

In our attempts to apply sound principles in construction, we have two things to determine:—first, the properties of the material we have to deal with, and second, the forms and conditions in which it should be applied. In regard to the former, it is essential to sound construction that we should have good material, and on this point it will be requisite to offer a few suggestions. To those acquainted with the iron trade, it is well known that we have five or six different sorts of plate and bar iron, namely, cinder plates, common plates, best plates, double wrought plates, and the superlatively good best-best plates. The same varieties may be had in bars, and it requires no small degree of skill and penetration to determine from appearance what is good and what is bad. One thing is, however, evident, that no description of plates or angle iron should be employed in ship-building that would not stand a test of 20 to 24 tons tensile strain per square inch. That these plates should be made from good puddled bars, piled and rolled at the proper heat, is also essential to durability and security in naval construction; and the additional cost of 20s. per ton should not be an object when compared with the superior quality of the iron employed. In fact, it is a mistaken economy to suppose that a reduced rate per ton in the first cost of an iron ship is an advantage. On the contrary, it involves in reality a serious loss; the inferior material can never be depended upon, and the risk incurred in consequence is too great to lend to its employment any countenance or support. On the other hand, when a better quality of iron is used, less weight is required, and the builder executes his work with greater exactitude and with less risk of injury to the material.

Fig. 1.

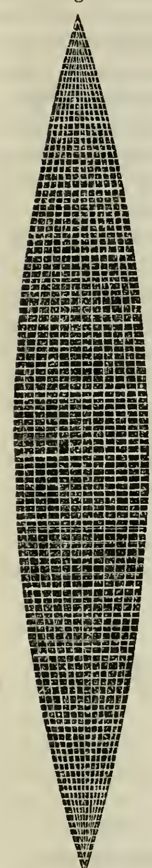


Assuming that the material is unexceptional as to quality, we have next to consider the principle on which large vessels, 500 ft. in length, should be constructed for the purpose of obtaining the maximum of strength with the least material. In this case it will be necessary to depart from the ordinary rules of construction, and instead of a closely packed series of transverse frames, it will be important to place the principal frames at distances of 4 feet apart, using the remainder of the material in the shape of longitudinal keelsons or stringers, as shown at *a a*, fig. 1.

Framing the hull of the ship in this form gives greatly increased stability, and in a vessel of this magnitude the whole of the material in her hull will be arranged in parallelograms, measuring at midships 6 feet by 4 feet, and narrowing

as they approach the stem and stern until the lines of the vessel bring them in contact, at which point two cells would run into one till the extreme points were reached at each end. If we remove the iron sheeting, the bottom of the ship will present a large honey-combed surface, as in fig. 2. Now of all forms this is the strongest, and a large vessel constructed in this way would have immense rigidity, and form one continued line of walls or girders, greatly in favor of the material, and adding much to the strength of the ship. Besides, in the above form the plates forming the keelsons and frames may be much reduced in thickness, and two-thirds of the transverse frames being dispensed with, we can afford to increase the number of longitudinal keelsons without increasing the weight of the material in the ship.

Fig. 2.



For comparison, let us estimate the strength upon this construction and that on the plan of frames 18 ins. apart, with only three longitudinal keelsons in the bottom. In the proposed improvement there are thirteen longitudinal keelsons, and these, with the outer and inner sheathing at the bottom, cellular deck, &c., would probably give a displacement of 4500 tons.

AREA OF BOTTOM.

	Ft.	Ft.	In.		Sq. ins.
1. Centre keelson	500 ×	6	× $\frac{3}{4}$	and angle iron	72
2. Keelsons	"	4	× $\frac{5}{8}$	"	90
4. "	"	$3\frac{1}{2}$	× $\frac{1}{2}$	"	132
2. "	"	3	× $\frac{1}{2}$	"	60
2. "	"	$2\frac{1}{2}$	× $\frac{1}{2}$	"	54
2. "	"	2	× $\frac{1}{2}$	"	48
Total keelson area,					456
80 feet of sheathing plates averaging $\frac{3}{4}$ in. thick,					720
60 feet interior sheathing averaging $\frac{3}{8}$ inch,					270
Total area of bottom,					1446

We suppose the upper part of the ship along the deck to be formed on the same principle as advocated for ships 300 feet in length in the previous lecture, with two cells near the centre, *b b*, and with two square and two triangular longitudinal cells, *c c*, at the side, extending the whole length of the ship, as shown in the section, fig. 1. We should then have with the stringer plates, deck planking, &c., the following sectional area:—

AREA OF THE TOP.

2 middle cells 20 ins. × 20 ins. × $\frac{3}{4}$ ins.	120	sq. ins.
2 side cells 30 ins. × 18 ins. × $\frac{3}{4}$ ins,	142	"
2 triangular side cells 36 ins. × 36 ins. × $\frac{3}{4}$ ins.	162	"
Angle iron to the above,	138	"
16 feet of plates on sides = 192 ins. × $\frac{3}{4}$ in.	144	"
Deck stringers 360 ins. × 1 in.	360	"
Deck planking, say	300	"
Total area of top,	1366	"

This gives an excess of 140 sq. ins. in favor of the bottom as a compensation for extra wear and tear on that part.

The strength of a vessel built in this form with the above sectional areas, and properly constructed to resist a lateral strain, may be found as before by applying the formula, $W = \frac{a\,d\,c}{l}$. With the constant 60 as before, and taking the smaller or deck area—

$$a = 1366 \qquad c = 60$$
$$d = 40 \qquad l = 500$$
$$W = \frac{1366 \times 40 \times 60}{500} = 6556{\cdot}8 \text{ tons},$$

the breaking weight at the centre, or 13,113·6 tons with the load distributed. Again, comparing this with the weight of the ship and cargo, and taking her loaded draft at 24 feet, we have a displacement of about 9800 tons, which, it will be observed, leaves a margin of strength of 3313 tons, sufficient for all practical purposes as regards the durability and safety of the ship.

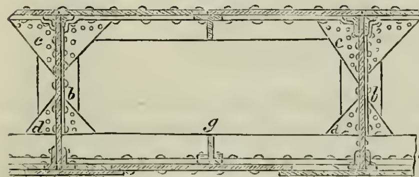
We could multiply these calculations to any extent, but I only wish to point out for the guidance of engineers what we consider the best and most effective principle of construction to insure a powerful resistance to strain, and a distribution of material capable of withstanding the shocks of a rolling sea, or any other trials to which in extreme cases the vessel might be exposed.

Water-tight bulkheads are of great importance in the class of vessels we are now considering. These not only bind the sides of the ships together from the keel to the deck, but they give rigidity and strength to the whole structure, and there is no part more deserving of attention in large ships than these bulkheads. In a ship of 500 ft. length and 68 feet beam, it might be desirable to divide her into two parts by a longitudinal bulkhead up to the middle deck. That would, however, be inconvenient in many cases in both sailing vessels and steamers. In fact, in the latter it would be inadmissible on account of her machinery; we must, therefore, deal with the construction under those conditions required by the service for which she is intended. This does not, however, affect the general principle that bulkheads made perfectly water-tight and stiffened with angle and T-iron should form component parts of the structure, and require great attention both as to the number of compartments and the position in which they are placed.

It now remains for consideration in detail whether the principle of longitudinal keelsons, with corresponding plate and cellular stringers, is or is not superior to the ordinary construction with transverse frames. In vessels of such immense tonnage it would appear from the formula applied to hollow girders that a great increase of transverse strength may be gained, as in the case of smaller vessels, previously considered. In a vessel floating on water the force of external pressure at a depth of 24 feet is about 1572 lbs. per square foot, or 11 lbs. per square inch, and this distributed over the surface of one of the

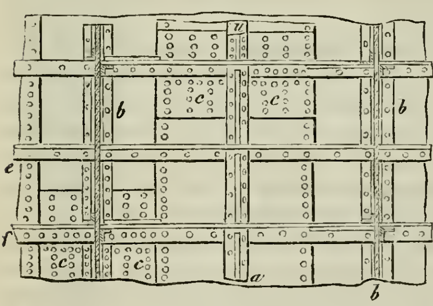
cells, 6 feet by 4 feet, amounts to 17 tons nearly, or is equivalent to a force of $8\frac{1}{2}$ tons at the centre of the cell at midships. Now this would be too great a pressure for a $\frac{3}{4}$-inch plate, and would cause a bulging inwards were it not for the counterpoising pressure on the adjoining cells, which has a tendency to neutralize the bulging tendency by straining the metal uniformly over the keelsons and transverse ribs. In order, however, to increase the rigidity of these parts, it will probably be necessary to run down the middle of each cell bars of T-iron, 6 inches by 5 inches, as shown at *g*, fig. 3, in the line of the keelsons, *b b*, composed of angle irons and vertical plates riveted to the sheathing plates 3 ft. wide and 12 ft. long. On this principle the T-iron would also rest upon the longitudinal plates, and the transverse joints would be covered by the plates shown at *c c*, fig. 4, placed under the frames and chain-riveted. The covering plate in this case being thicker than the sheathing plates, in order to compensate for an increased number of perforations for rivets along the line of the joint.

Fig. 3.



It has been stated that it would be necessary to have an increased number of transverse frames, in order to bring the lines of the vessel into shape; should this prove correct, another light rib may be used, as shown at *e e* in the plan, fig. 4, riveted to the sheathing on the same principle as the other ribs, *f f f f*, which are 4 feet asunder. These practical details, however, we may leave to the judgment of the builder, as not essential to the stability of the ship. In this way the resistance of the cells to bulging would be more than doubled, and the whole of the cellular construction rendered secure under every form and condition of strain. The preceding sketch (fig. 3) represents the sectional form of the cells, each of which may be stiffened by gussets, *a a* and *d d*, riveted to the angle iron of the keelsons and transverse frames. Fig. 4 shows in plan the keelsons, *b b*, ribs, *f f*, additional rib, *e e*, T-iron along the bottom, *a a*, and covering plates, *c c*, chain-riveted. On this plan the cells would be open from one bulkhead to the other, and with proper water-tight manholes between each bulkhead might, if necessary, be used for stowage or for the insertion of tanks in which fresh water might be kept ready for use.

Fig. 4.

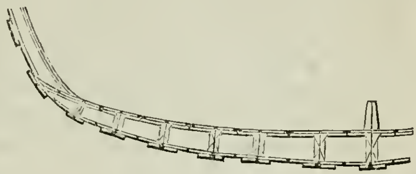


On the above construction the sheathing plates would be lap-jointed, using the keelson angle irons and the intermediate T-irons as stiffen-

ers for the cells, as shown in fig. 5, which represents one-half of the cellular system at the bottom of a vessel from the keel to the turn of the bilge.

Enlarged covering plates, chain-riveted for the transverse joints, are of great importance both in regard to the lateral and longitudinal strength of the ship. The resistance to tension would be one-sixth greater than with the ordinary construction, and thus the security of the ship would be greatly increased.

Fig. 5.



As regards the upper and intermediate decks, there would be no change except the introduction of two cells, one on each side of the hatchways, and four other cells, two on each side of the ship, as shown in fig. 1. In the sectional area of the upper deck it will be observed, that in the previous calculation we allowed about one-sixth as the value of the deck planking in resisting a compressive or tensile strain, and that we made a further allowance of material to the bottom to compensate for the wear and tear of those parts. Hence, the sectional area of iron in the upper deck will be to that in the bottom in the ratio of 4 to 6. These proportions have been assumed, but they are in accordance with experimental researches, or at least so far as we have results bearing on this question; and it only requires an extension of such experimental investigations to prove how far these proportions approximate to the correct ratio for resisting the strains at those parts respectively.

A series of well-conducted experiments of this kind is much wanted, and a Government grant of £1000, with a similar grant from Lloyds and from the shipowners fund, would set the question at rest, and establish in shipbuilding, as in other constructions, true principles, the correct expression of physical laws. It is with the object of aiding in the attainment of this that I have ventured to make these suggestions. The subject is one of deep importance to the community, one on which we are very deficient in knowledge, and one which will reward investigation, and that with great benefit to the public and to mechanical science, and without injury to existing interests.

Impressed with the conviction that we are still laboring under difficulties from a want of knowledge of the true principles of naval construction, we are encouraged from other movements in looking forward to the time when these difficulties will be removed, and when greater economy in the distribution of the material will be accomplished from the reduction of the whole system of shipbuilding to the exact laws of science.

In the discussion of this question I have not ventured to inquire into the applicability of the cellular construction to ships of war, and my reason for the omission has been that the effect of shot upon iron ships has yet to be decided upon. I am aware that the Admiralty some years since came to a conclusion adverse to the use of iron, which

I am not now prepared to call in question. But the improved condition of our iron constructions, and the increased tenacity of the material, taken in connexion with our improved system of gunnery, may afford reasons for altering that decision, and lead to results favorable to the use of iron as a material for building vessels of war.

With the Whitworth rifled gun, for example, with an oblong flat-ended missile, iron is penetrated by a process that drills or cuts out the core without splintering or tearing up the surrounding surface; and looking forward to still further improvements, the iron ship may be increased with safety under the influence of a more destructive arm than has heretofore been used. Be this as it may, the same principles of construction will apply to the navy as to the vessels of the merchant service; and till it has been more conclusively proved that iron is inapplicable to the construction of ships for the purposes of war, we may reasonably conclude that this material may ultimately become the best safeguard of Her Majesty's dominions at home and abroad.

Destructive Action of Minium on the Hulls of Iron Ships. Letter from M. Jouvin to M. Dumas.

From the London Chemical News, No. 86.

The observations I made last March on the iron hull of the Imperial packet *Guienne*, are confirmed in every point by those furnished by the hull of the packet *Le Bearn*. At first sight there was such strong resemblance between the state of the two hulls, that they seemed identical; but by going into details, the following differences were observed:—

The whole of the hull of *Le Bearn*, which has received a coating of minium, has become dull red; the vivid tint of oxide of lead is extinguished in a vague color, as if washed out, or as if the painting had been covered with a sort of grey glazing. On this ground scales of hydrated oxide of iron stand out in relief, and are just as numerous and large as in the case of the other vessel. On this occasion I found that the layer of oxide of iron was much thicker at the corners and edges of the sheet iron plates than elsewhere, although the friction must be greater on these prominent parts. This fact escaped my notice with the hull of the *Guienne*.

I think the bubbles are as numerous on the rest of the coat, if not so large as on the *Guienne*. These bubbles may be always divided into two kinds:—

1. Bubbles containing some drops of liquid.
2. Bubbles without liquid, and containing merely air or a gas.

The latter are remarkable for being covered at their base with minute crystals of lead, overlaid with a thin coating of hydrated oxide of iron or yellow ochre. The internal surface of the pellicle of which they are composed, examined with a lens, shows needles of chloride of lead in the midst of slight concretions, which have the appearance of "horn lead" of mineralogists. *Kéraisne.*

The concretions of chloride of lead, which I found afterwards at the base of both kinds of bubbles, on the iron hull, imbedded in magnetic oxide of iron, the dark color of which they relieve by their slightly amber tint.

The liquid contained in the other bubbles I have subjected to a more careful examination. Tested *in situ*, it slightly reddens litmus paper. To the taste at first it is freely styptic and rough, a taste due to the ferrous chloride, as I said in my first paper; to this soon succeeds a sweetish taste, resembling a weak solution of acetate of lead. In my observations on the *Guienne* I recognised, by this taste, the presence of a dissolved salt of lead in the liquid contained in the bubbles. I did not mention it at the time, because I had not determined its nature.

In order to find out, I collected a certain quantity of the liquid by absorbing it with a piece of blotting-paper, when it became easy, by means of distilled water and re-agents, to determine that the liquid consisted of a solution of ferrous and flambic chlorides. Do not these two chlorides form a true soluble saline combination? I am strongly inclined to this opinion. When occasion serves, I propose to revert hereafter to this study. One fact which my experience has taught me is, that solutions of ferrous chloride become, by contact with minium, charged with chloride of lead, as may have been easily foreseen.

The liquid of the bubbles, when exposed to air, quickly becomes covered with a thin pellicle of sesquioxide of iron, without precipitating the slightest trace of chloride of lead. This salt does not appear until only a trace of liquid remains at the bottom of the capsule. By means of the microscope, and even with a lens, it is easy to detect in the midst of the sesquioxide of iron the play of colors of the micaceous spangles of this salt, the deposit of which in the capsule seems to me to be effected in the same manner as if the bubbles were dried.

There was a degree of regularity in the disposition of the concretions on the hull of the *Guienne* which was not to be found on that of *Le Bearn*. In other respects it presents exactly the same foliated structure; it has always externally and at the moment of immersion the same gray color of the iron; then, under this thin envelope, yellow ochre; and at the base the dark green of hydrated ferrous oxide and ferroso-ferric oxides. In all these points the concretions on the two vessels were almost identical. We shall likewise soon establish their chemical identity.

To conclude. Two chemical experiments on a very large scale have been originated in the workshops of La Ciotat. 1200 square metres of sheet iron, covered with linseed oil, and mixed with minium for the first layer, and the same preparation, with the addition of mercuric sulphate (7·5 per cent.), for the second layer, have been launched on the sea: that is to say, that, endowed with a positive electrical polarity (for the hold itself is also painted with minium), this gigantic electrical pair, forming at the same time a kind of condenser, has been plunged into a solution of alkaline chlorides saturated with air. It has then made two or three voyages to Brazil, touching successively at Lisbon,

St. Vincent, Pernambuco, and Bahia, to go into port according to circumstances, either at Rio or Bordeaux. During these long voyages this hull, besides the friction of the water and the shock of the waves, has undergone great inequalities of temperature, which must have caused prodigious dilatations in its metallic sides.

We have now before us the results of these two experiments:—

1. A considerable quantity of oxides of iron (ferroso-ferric oxide predominating) either in concretions or pulverulent.
2. Ferrous chloride.
3. Plumbic chloride.
4. Metallic lead.

Chemical analysis has not hitherto enabled me to discover more than this, either in the concretions or bubbles, besides, of course, minium and the oily menstruum.

The following is the mean of ten analyses made by the same process and under the same conditions:—

	Concretions of the Guienne.	Concretions of Le Bearn.
Sesquioxide of iron, . .	72·45	70·54
Ferrous chloride, . .	2 85	2·86
Plumbic chloride dissolved by ferrous chloride	2·80	2·52
Oxide of lead mixed with chloride, .	7·30	4·95
Alkaline chlorides, . .	0·87	1·42
Organic matter, . . .	3·73	4·99
Water, . . .	10·00	12 72
	100·00	100·00

What has become of the mercuric sulphate? Hitherto I have failed to discover any traces of it. The transformation undergone by this salt by reason of the oil with which it is mixed, will be made the subject of another paper.—*Comptes Rendus.*

Nitrate of Soda at Iquique (Peru).

From the Journal of the Society of Arts, No. 476.

As Iquique is the centre of this trade, and to it its present importance is wholly to be attributed, it is thought to be advisable to convey in this paper as much information as can be procured as to this article, and in order that such information shall be truthful, the writer has availed himself of the views of several Englishmen at present engaged in the trade.

About from six to fourteen leagues from the coast, and running parallel with it through the province, at an elevation of 3300 feet or thereabout, is the Pampa of Taramugal. This plain or pampa was a sea lake, and the greater part is covered with salt along the western border; and generally not extending eastwards more than 500 yards from the verge of the old lake is found the "caleche" or "terra sali-

trosa," rough nitrate. Between the pampa and the coasts exists other old sea lakes, on the borders of which "caleche" is also found; but these deposits are of secondary import. The "caleche" is generally found in insulated masses, irregular in shape and thickness, which adds greatly to the expense of working. It is sometimes found with only a few inches of sand over it, but more frequently covered with a hard stone, consisting of sand indurated with salt; this is called "costra," the thickness of which varies from one to ten feet, but averages three feet. The "caleche" varies in thickness from one to nine feet, but in general runs from three to four feet; below this exists a soft sand, containing an abundance of crystals of glauberite and small quantities of borates of lime and soda. The strata consist of

1. Loose sand, a few inches thick.
2. Hard sand, indurated with salt, from one to ten feet thick.
3. "Caleche," from one to nine feet thick.
4. Soft sand, or cora.

The "caleche" varies in quality from nearly pure salt to 50 and 60 per cent. of nitrate, generally containing the following substances:—

Earthy matter.
Nitrate of soda.
Chloride of Sodium.
Sulphate of Soda.
" Lime.
And traces of Chloride of Magnesium, and
Iodides and Bromides.

It is impossible to state the respective proportions, as they vary with every different sample. The method of extracting and refining nitrate of soda is as follows:—

When "caleche" is required, the barretero (miner) makes holes in the ground where he expects to find it. If successful, he fills up the holes with coarse gunpowder made on the spot (costing three and a half dollars per quintal), regulating the charge in proportion to the thickness and hardness of the "costra" and the thickness of the "caleche;" the charge varies from one to eight quintals, and occasionally as much as fourteen quintals; when blasted the whole mass is turned over and mixed. He then proceeds to separate the "costra" and "cora" from the "caleche," throwing aside all the latter that he does not believe to contain more than ten or twelve per cent. of nitrate; it is then broken into smaller lumps, to be conveyed to the "paradas." A refinery of nitrate is called an "Officina," and is generally placed in the centre of the calecheros or nitrate grounds, and consists of one or more paradas; a paradas is a pair of round iron boilers, each holding from 70 to 300 gallons; these are placed together, in rough stone-work, with a fire-place between them. At the parada, the acendrador breaks the lumps into pieces about the size of a fist, rejects the inferior pieces, so as to bring the whole to about 25 to 35 per cent. of nitrate. It is now thrown into the boilers with a quantity of water; after boiling some two or three hours, the fondeador (boiler), continually stirring the mass, supposing that the "caleche"

is by that time exhausted, throws out the ripio (refuse), adds more "caleche" and mother-water; and, after boiling some two or three hours, a well saturated solution is obtained; it is then by hand baled into a deposit, from whence, as soon as the mud and salts are deposited, it is baled into shallow coolers, where it crystallizes. The mother-water is then drawn off, and the nitrate thrown out to dry. The paradas are charged twice a day, and the daily product is from fifteen to twenty quintals of nitrate, containing about 3 per cent. of impurities, chiefly common salt. The average cost of a quintal of nitrate is:—

Barretero, breaking out, . .	12½	cents.
Acendrador, assorting, . . .	6¼	"
Fondeador, boiling, . .	12½	"
Powder for blasting, . . .	6¼	"
Asses bringing the caleche to the paradas, .	3	"
20 lbs. coals at $1·50 per quintal, . .	30	"
Wear and tear of parada, reparations, and depreciations,	29½	"
	100	"

This system of making nitrate is the same as was first adopted at the commencement of the trade, and unquestionably well adapted for that early period, having the advantage of being simple, easily understood and worked; yet it is still continued, and the whole system of labor arranged to it. It is almost impossible to conceive a system more rude and more wasteful; and although many exertions have been made during the past ten years without success to improve it, yet that want of success has been caused chiefly by the lack of skilled labor in the province; still there is no doubt that it will be superseded, in the course of a few years, by the more refined and complicated apparatus now being introduced.

The theory of the process of refining nitrate is this:—

"Caleche" consists of nitrate of soda, chloride of sodium, (common salt) and earthy matter (the other substances present exist in such small quantities that they are overlooked); and as chloride of sodium is very little more soluble in boiling than in cold water, whilst nitrate of soda is comparatively insoluble in cold but very soluble in hot water, it is very evident that it is only required to add such quantities of "caleche" to boiling water to procure a strongly saturated solution; the earthy matter, being insoluble, is left with the excess of common salt in the boiler, or the deposit, before it is discharged into the coolers, where, as the liquid cools, it deposits the excess of nitrate of soda, the mother-liquor retaining nearly all the salts in solution. Reverting to the customary process of refining, two systems are now being tried, which use steam; in the one (Gamboni's patent) the "caleche" is placed in an inverted semi-cone, with a perforated cover and bottom; through the side a jet of steam is introduced, mother-water is thrown on the cover, and the refined nitrate falls through the bottom, and is at once conveyed to the coolers; in the other, steam is introduced to boil the solution, but both promise the same advantages—economy in the make and a superior article.

No sketch of the nitrate trade would be complete without some re-

ference to the abuses. In the first place, it is badly based. The merchant makes advances to the salitreros, or officineros (makers), of money and goods, on the promise of receiving in return the product of the officina. This advance frequently is used in paying off old debts, or in advances to the laborers. The merchant must still keep advancing barley for the troops, coals and provisions for the laborers, &c., or there will be no nitrate forthcoming. This system trenches heavily upon the merchant's resources, and occasionally leads to losses. The officineros, as a body (with some exceptions), are a reckless set of men, wasteful in their expenditures and careless of their promises. Their arrangements with their laborers are also bad, their principal ones, the barretero, acendrador, and fondeador, being paid according to the product of the parada; recriminations are ever recurring, and not unfrequently leading to a closing of the works. Another thing must also be noticed—the great amount of adulteration that has taken place within the three past years. Rarely a cargo leaves that is less worse than 5 per cent., some even 7 to 10, and some samples assayed have shown as much as 30 to 50 per cent. of foreign matter. The adulteration is effected in two ways; in one, white "caleche" is ground and mixed with the refined nitrate; this is called green nitrate: the other, the powdered "caleche," is mixed into the solution, and at once put into the coolers; this is dirty nitrate. This is in some measure protected by the present state of the trade. Merchants in England purchase from the importer, and get a deduction from him corresponding to the amount of foreign matter in the article; but as the general sales are made without any deduction, then the worst cargoes are the most profitable to the merchants.

The province has not been thoroughly surveyed; but enough "caleche" has been discovered to yield an increased supply for ages. In May, 1856, there were about 100 officinas at work, with about 250 paradas, but the work is not constant; 240 days is a good year's work. The principal sales of this article are made in Valparaiso on the usual terms, viz: ore well sacked, not to contain less than 95 per cent. of nitrate, placed in the ship's launch outside the surf. The price has been very fluctuating, commencing at 18 reals, rising to 20 reals, falling to 16 reals, and then in four months rising to 23 reals, but taking an average price of 19 reals; 936,719 quintals, with the exchange at \$46, would give £426,402 5s. 16¾d. The other salts found in the province are chloride of sodium, biborates of lime and soda, sulphates of lime and soda, magnesian alum, &c. Iodine exists with the nitrate, and throughout the calecheros traces of boracic acid have been found in the water.

Accident to the Iron-clad Steamer Defence.

From the London Artizan, March, 1862.

On the morning of the 22d ult., a serious accident occurred to her Majesty's ship *Defence*, which ship was lying at Spithead. It appears that the *Hunter* gunboat left Portsmouth Harbor on the above morning, and steamed out to the *Defence*. There was a heavy swell run-

ning at the time, and it is asserted that as the *Hunter* went alongside, miscalculating her distance, she ran towards the bow of the ship, the bower-anchor of the latter just touching her side. As the swell lifted the gunboat, it caught the anchor, which broke away from the tumbler, and, after being dragged away by the gunboat, rebounded against the bow of the ship, into the side of which the fluke completely picked a large hole. The iron at the bow is only five-eighths of an inch thick. It is stated that one of the pieces of iron knocked out has been examined, and found to be greatly deficient as regards the welding.

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*Disengaging Catch for the Miner's Safety Cage, &c.** By Robert Aytoun.

From the Lond. Civ. Eng. and Arch. Journal, March, 1861.

All previous disengaging catches with which I am acquainted, are subject to the serious defect of disengaging sometimes when it is not wanted, or of not disengaging when it is wanted; and the means taken to remedy the one defect only make the other more imminent.

The catch which I have invented (Figs. 1, 2, and 3) is entirely free from these faults. It may be described as a species of clasp-knife, which it resembles both in form and the duty it has to perform—viz: that of cutting through an iron bolt, so as to allow the cage being disengaged from the winding-rope, as after mentioned. Its handle, A B C, Fig. 1, and blade, A D E, consist almost entirely of three steel plates closely touching each other. The handle is formed of the two outer

Fig. 1.

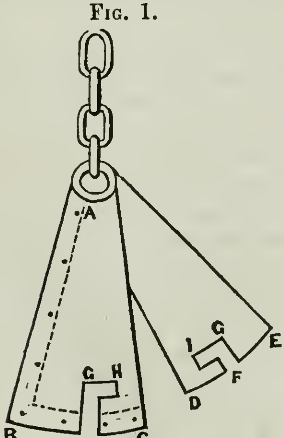
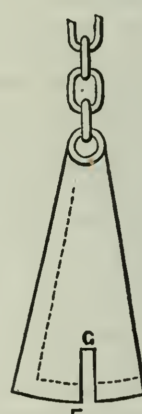


Fig. 2.



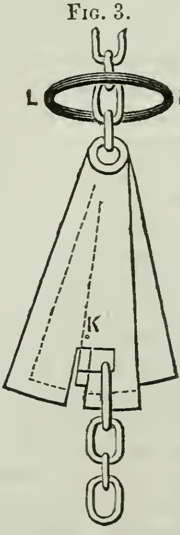
plates, which are separated, as usual in knife handles, by a spring along the back, and which is marked off by dotted lines in the figures. The mid plate represents the blade of the knife, which is not kept shut by its spring as in ordinary knives, but is slightly open. The pin, A, on which the blade turns, serves as the bolt of the shackle, by which it is attached to the winding-rope. The shackle end of the catch is

* Read before the Royal Scottish Society of Arts.

no wider than is necessary for strength. But the lower ends, both of handle and blade, B C and D E, are made somewhat wider, to admit of slots being cut into them, to serve as hooks for suspending the cage. The slots are made thus: having shut the catch, by pushing the blade home into the handle, as in Fig. 2, a vertical slot, F G, is to be cut from the middle of the lower end, right through both handle and blade, of a size sufficient to admit the link by which the cage is to be attached to it. The length of the slot may be twice its width. The blade being now opened, as in Fig. 1, the slots of both handle and blade are to be extended from their upper ends in the direction of each other, that is to H and I respectively. The length of these extensions need not exceed their width.

The action of the slots is as follows:—the catch or knife is first shut, which brings the vertical slots both of the handle and of the blade together, so as to form only a single opening, as in Fig. 2. The link by which the cage is to be fastened to the catch is then pushed up to the top of the vertical slot. Next, the blade is allowed to open by the operation of its spring, by which means the vertical slots, both of the handle and the blade, are moved away from under the link, which now finds itself at the extremities of the side extensions of the slots, resting on their lower sides, as in Fig. 3. In this situation the junction of the cage to the rope is perfect. But its security depends entirely upon the spring; for if it were to allow the blade to shut, the two vertical slots would be brought together, and allow the link to escape, and the cage to drop. To prevent the occurrence of this mishap, to which all previous disengaging catches are liable, a strong bolt of soft iron, whose head is shown at K, Fig. 3, is passed through both handle and blade, and strongly riveted. This secures the catch beyond the possibility of accident, and gives as much security as any link or shackle could do. At the same time, the bolt may be cut, and the blade shut so as to liberate the cage, by the application of sufficient power. For this purpose, a strong iron ring, L M, Fig. 3, within which the winding-rope travels, is secured close below the pit-head pulley. Its diameter is just sufficient to admit of the catch passing through it when closed. In the case of over-winding, when the catch impelled with the whole force of the steam engine and the momentum of the flywheel, reaches the iron ring, the blade is at once shut, and the bolt sheared cleanly through, and the cage released. This is shown in the model, in which a bolt of copper is cut through at each experiment. The bolt is not broken, in which case it might be feared that sometimes it would stand the shock and not liberate the cage; on the contrary, it is as cleanly cut as if done with shears provided for the purpose. The reason is obvious; the handle and blade of the catch are composed, as was stated before, of three plates of

FIG. 3.



steel, fitted closely together, and drawn still closer by the riveted bolt, which will not let them part till the cutting of the latter is completed.

I shall have thus, I hope, established my two positions, that the catch cannot be disengaged by accident, and that it cannot fail being disengaged in a case of over-winding. I am happy to be able to add that I have not secured the disengaging catch by patent.

Translated for the Journal of the Franklin Institute.

On the Probable Cause of those Explosions of Steam Boilers called Fulminating. Academy of Sciences of Paris.

Under this title, a note was presented by M. Mangin, the substance of which is as follows:—

It results from the admirable experiments of M. Dufour, that the temperature of water may, under certain circumstances, be brought to 178° Cent. (352·5° Fah.), without the production of boiling. These circumstances are the insulation from contact with the vessel, and insulation from contact with the air. Ebullition is produced by contact with a solid, that is, by the disturbance of the molecular equilibrium, and there is then a sudden evolution of steam. Nevertheless, every solid contact is not equally efficient in producing this change of state, and it results from the experiments of M. Dufour that isolation from contact with the vessel is not absolutely necessary for the production of the phenomenon. What appears to be indispensable is that the water shall be deprived of air, that the operation shall be carried on slowly, and that the heated mass shall be withdrawn from external disturbing causes. Having explained these preliminaries, let us see how the explosions called *fulminating* are to be explained.

These explosions take place only when the machine has been for a greater or less time at rest, and generally at the moment when they are about to resume the movement of the machine; and the boiler by its complete quietness gives no indication of the event. It is enough to open the throttle-valve, or one of the gauge-cocks, or the door of the furnace or ash-pit, or, in fact, any disturbance of the unstable equilibrium which has been established, to decide the catastrophe. It has also been remarked that, before the explosion, the pressure in the boiler is rather low than high. What, then, has taken place?

When the machine was stopped, the pumps were also stopped; the furnace and ash-pit doors were closed, as were all the escapes for steam or water. The ebullition continued, the safety-valve acted, and the water which had recently been pumped in, was purged from air. Then when the activity of the fire had fallen sufficiently, the valve fell into its seat, and the apparatus assumed a state of repose. If the atmosphere was calm, the draft null, and the escapes of water and steam hermetically closed, the apparatus (allow me to use the figure) has gone to sleep, and the molecules of water being at rest, the temperature has gradually been raised to a point notably above that of evaporation under the existing pressure. As the water produces no steam,

that pressure may be and may keep below that necessary for the action of the safety-valve. Things being in this condition, let any cause whatever disturb the equilibrium of the molecules, and all the heat stored up in the liquid mass is instantly employed in producing an enormous volume of steam, while the mass of water not evaporated falls to the temperature corresponding to its pressure.

Figures will easily account for the violence of the explosion which takes place. Let us suppose, in fact, that the pressure in the boiler, before the explosion, was 4 atmospheres, and that the temperature, in the quiescent state of the water, was only 170° Cent. (338° Fah.) As at 4 atmospheres the temperature of the water and steam is 145° Cent. (293° Fah.), each kilogramme of water in the boiler contains 25 units of heat above its normal quantity. Therefore, the moment this heat was liberated, it must have converted into steam $\frac{25}{606{\cdot}5+0{\cdot}305\times145-145}$ or nearly $\frac{1}{20}$th of a kilogramme of water; that is, about one-twentieth of the mass of water in the boiler was suddenly converted into steam.

Now, if we suppose that the volume of water in the boiler was double that of the steam, a quantity of water equal to one-tenth of the volume of the steam is suddenly vaporized; and as, at a pressure of 4 atmospheres, 1 volume of water produces 477 volumes of steam, the volume of the steam will be increased 47 times, and the pressure will be 188 atmospheres. It will be conceived that against such generations of steam, the safety-valves are of no effect, and that the explosions are really fulminating.

This manner of looking at the phenomenon leads to the suggestion of the following precautions. To prevent the *torpor* of the water, let the boiler be so arranged that there shall be a constant circulation kept up by the difference of temperatures of different parts. A second precaution easily taken is never to close a boiler when at rest, hermetically, but to keep the safety-valve slightly raised, or a steam-cock a little open, so that a small quantity of steam may always be forming.

On the Solidification of Carbonic Acid. By MM. A. Loir and Ch. Drion.

From the London Chemical News, No. 84.

In a paper read before the Academy, June 2, 1860, we stated that atmospheric pressure liquefies carbonic acid when its temperature is reduced to the point at which liquid ammonia evaporates *in vacuo.* By slightly modifying the conditions of the experiment, we have succeeded in solidifying carbonic acid with the aid of an apparatus as simple as those daily employed in chemical laboratories. This hitherto dangerous and costly operation may in future be easily repeated to a chemical class.

If liquid ammonia is introduced into a glass globe, and the interior of this put in communication with a good air-pump, by the intervention of a vessel containing coke impregnated with sulphuric acid, the

temperature of the liquid is rapidly reduced from the first strokes of the piston. The liquid begins to solidify towards — 81°; it soon becomes a mass, and if the air-pump allows the reducing of the pressure to about a millimetre of mercury, the temperature of the solid ammonia becomes lowered some degrees more and reaches — 89·5°. This suffices to determine the liquefaction of carbonic acid under atmospheric pressure. We have, in fact, proved that carbonic gas liquefies by passing a current of the dry carbonic acid gas into a small U-shaped tube, immersed in ammonia; but as the temperature obtained is only a few degrees below that of saturation, we get only a small quantity liquefied. If, on the contrary, a slight elevation of pressure is employed, the experiment becomes easy, and yields in a short time notable quantities of solid carbonic acid. The following is the manner of operating:—Introduce about 150 cubic centimetres of liquid ammonia into a reversed glass receiver, the sides of which are cemented to a plate with two holes. In the central opening fit a glass tube, closed internally, and reaching the bottom of the receiver, the other opening serving to place the interior of the receiver in communication with the pneumatic machine. Carbonic acid is produced by heating previously dried bicarbonate of soda in a copper retort, the neck containing fragments of chloride of calcium. One part of this retort communicates by a leaden tube on one hand with the tube which is immersed in liquid ammonia, on the other hand with a small manometer of compressed air. The air being previously expelled from the apparatus, and the temperature of the ammonia lowered to about the point of solidification, the retort is heated, noting meanwhile carefully the pressure. The pressure is thus maintained between three and four atmospheres. Rapidly augmenting transparent crystals soon appear on the sides of the interior tube, so that in about half an hour all that portion of the tube which is plunged in ammonia becomes covered with a thick stratum of crystals (about 25 grammes). The experiment may then be concluded and the apparatus dismounted.

Solid carbonic acid, obtained under the above mentioned conditions, appears a colorless mass as transparent as ice. It is easily detached from the sides of the condensing-tube by means of a glass rod; it then divides into large cubic crystals, each side about three to four millimetres. Exposed to the air, these crystals slowly return to their gaseous state; they evaporate, leaving no residue. Placed on the hand, they communicate no immediate sensation of heat or cold; they are with difficulty held in the fingers, and with a slight pressure escape as if covered with an unctuous matter. If one of these crystals is kept between the thumb and forefinger, it soon produces an intolerable burning.

An experiment was performed by placing a certain quantity of solid carbonic acid in a small glass tube communicating with a receiver filled with mercury. After some time the crystals disappeared, leaving no residue, while the receiver was filled with perfectly pure carbonic gas, capable of being completely absorbed by potash. Mixed with ether, in a small porcelain crucible, these carbonic acid crystals yield a freezing mixture of a temperature of — 81°.

As a conclusion to these summary indications we will add that the liquid ammonia used in our experiments was prepared by M. Bussy's process,—that is to say, by acting on ammoniacal gas in a globe surrounded with liquid sulphurous acid, the evaporation of which is expedited by an air-pump. By this method nearly two decilitres of liquid ammonia can be easily obtained in less than two hours.

We determined the temperatures here indicated by means of an alcoholic thermometer, on which we marked two fixed points,—that is to say, 0° at melting ice, and —40° at the temperature of melting mercury.—*Comptes Rendus.*

On the Boiling-points of Liquids. By M. L. Dufour, of Lausanne.

From the Lond. Chemical News, No. 84.

It is an established fact that the temperature of boiling water, instead of being always the same, or varying only with the atmospheric pressure, differs according to the vessel in which the liquid is heated. For instance, water boils sooner in a metal than in a glass vessel, and M. F. Marcet's numerous experiments (*Bibliothèque Universelle*, vol. xxxviii. p. 381) have shown, amongst other things, that the treatment a glass vessel has undergone (as washing in sulphuric acid, &c.) causes several degrees of variation in the boiling point. Water deprived of the air dissolved in it can be re-heated considerably above 100° C. before becoming gaseous, but then it boils violently. Donny, in his interesting experiments (*Annales de Chimie, et de Physique*, third series, vol. xvi. p. 167), carefully heated water completely freed from air, to 135° before a change of condition took place. This retardation of ebullition is manifested also by other liquids, and the production of vapors by starts is a frequent sign of it in glass vessels.

In the actual state of things, boiling produced at a higher temperature than that at which the elastic force of the vapor of the liquid is equal to the external pressure is generally considered as an anomaly due to two causes,—first, the adhesion of the liquid to the substance of the vessel; secondly, the absence of air in solution. There are, however, some curious facts, which show that the adhesion of a solid and the absence of air in solution are inadequate to explain the retardation in boiling; but on the contrary, contact with a solid produces an immediate and decided formation of vapors. If a few drops of water are dropped into linseed oil, heated to 105° or 110° in a porcelain capsule, they fall slowly to the bottom of the vessel. The instant they reach it, vapor is formed suddenly; the slightly diminished drop of water rebounds several millimetres from the bottom, then falls again, causing another disengagement of vapor; again it rises, and so on. Now, it must be remarked that the drops of water, while floating in the oil, before touching the bottom of the vessel, undergo no perceptible evaporation, and that it is only on their contact with a solid that there is a sudden production of a bubble of vapor.

It will, then, be asked, What would happen were the water, while being heated, kept away from the sides of the vessel, floating freely in a medium of a density equal to its own? The proper medium to be

employed in these experiments ought to be able to bear temperatures above 100° without boiling, to be about the same density as water, and not to mix with water. Oils will not do, but certain essences sufficiently fulfil these conditions.

Essence of cloves, with a little oil added, forms a liquid in which water maintains its equilibrium in perfectly rounded drops, and moving about freely in the interior. Carefully heated, the mixture always passes 100° C., and sometimes goes much higher, before the water boils. It is easily and constantly raised to 120°, 130°, and even higher. I have many times raised the temperature of aqueous globules of ten millimetres in diameter, to 140° and 150°. Minute globules, from one to two millimetres in diameter, have several times reached 170°, and even 175°,—that is to say, to temperatures at which the elastic force of aqueous vapor is more than eight atmospheres. I am speaking here of water which has undergone no preparation, which has been neither distilled nor freed from air. At these high temperatures the globules do not undergo, as might be imagined, slow and continuous ebullition; they are as quiet and limpid at 150° as at 10°; it is rather the liquid state continued much beyond the limits corresponding to the pressure under which the operation is performed.

Ebullition is produced when the globules come in contact with a solid. If, drawn by the currents which heating inevitably occasions, they strike against the sides of the vessel or the bulb of the thermometer, there is suddenly formed a bubble of vapor; the globule, become rather smaller, is projected violently from the point at which it produced this kind of explosion, and then continues floating in the medium. The result is the same if, when the temperature is above 115° or 120°, a globule is touched with a glass or metal rod; an explosion is produced at the point of contact, a bubble of vapor is disengaged and passes through the essence, and the globule touched rebounds as though the solid point exercised a sudden repulsion over it. However, all solids are not equally efficacious in producing this change of state; glass or metal rods sometimes fail, but a slender wooden or charcoal stick always incites an immediate and tumultuous ebullition in the middle of the overheated globules. Contact with saline crystals is generally very efficacious.

It is difficult to preserve large globules from contact with the sides; hence they are the seat of the formation of vapor on one point of their surface, which has the effect generally of breaking them up into smaller globules. In my experiments, the vessels employed were small glass globes, and I have already easily obtained a globule of eighteen millimetres, at 130° C., and others of six to ten millimetres at 150° C., &c. The smallest globules most readily escape contact with the sides, and can be submitted to a higher temperature.

It may well be supposed that the preceding facts may be realized with other liquids if heated under proper conditions. This supposition is confirmed by the experiments I am now making. For instance, chloroform, heated in a concentrated solution of chloride of zinc, easily reaches 90° and 100°. The chloroform globules float lightly

in this liquid, like water globules in essence of cloves. Beyond 70° contact with a solid rod produces decided and violent evaporation.

It is difficult not to connect these facts with those in which contact with a solid causes the crystallization of super saturated saline solutions, and also the sudden solidification of water, sulphur, &c., when brought below their ordinary temperature for solidifying. It is equally difficult to disconnect them from the facts which I have lately had the honor to bring before the Academy,—facts which showed that liquids resist solidification when immersed in a fluid medium. It appears that contact with a solid determines a change of state in liquids, and it may be that the limits of temperature assigned to the various conditions of bodies are not so absolute as they seem. Our experiments on liquids, always made in vessels in contact with solid bodies, may perhaps have led us wrongly to consider, as inherent properties of the liquids themselves, the phenomena resulting, at least in part, from the presence of solids. Thus, when water floats freely in a fluid it rarely freezes at 0°, and it is only changed into vapor at a point of the thermometric scale always exceeding 100°.—*Comptes-Rendus.*

Preservation of Meats.

At the last meeting of the Society for the Encouragement of National Industry, M. Peligot read the following note of M. Martin de Lignac on his new patented process for the preservation of meats:—

In the usual way of salting, the meat is placed first in salt and afterwards in the pickle. The salt absorbs the liquids in proportion as they separate from the flesh, then the pickle penetrates by endosmose, and preserves them from any subsequent alteration by its antiseptic properties. But in this case, the salt acts on the surface a long time before it penetrates to the centre, whence results an excess of salt at the surface, whilst the centre is not sufficiently salted and still contains the principles of fermentation. To avoid this, the habit is to cut up the meat, but this, while it increases the chances of its preservation, greatly alters its quality. In fact, the salt in contact with large surfaces absorbs too largely the liquids contained in the flesh, and extracts from them the aroma and a portion of their nutritive juices. Pork, the tissue of which is dense and protected by fat, bears this preparation better than beef, the flesh of which after long standing in the salt, presents only a fibrous tissue without flavor and with but a low nutritive power.

It results from these facts; first, that meat preserved by the usual process contains necessarily too much salt, and that its prolonged use is injurious to health; secondly, that it loses a part, sometimes a notable part of its nutritive value.

The method of avoiding these inconveniences is to salt uniformly and not subdivide too far the meat, thus preserving its aroma and its juices; I think that I have found the solution of this problem, and the following are the means which I employ:

If it is a ham which I wish to salt, I introduce, by means of a trocar,

between the bone and the muscle at the small end, a sound which I attach to a stop-cock which communicates by a tube with a reservoir of water saturated with salt, to which are added various aromatics and condiments. The reservoir is from 25 to 35 feet high. When the stop-cock is opened, the liquid by its pressure rapidly separates the muscle, and the two or three ounces of pickle which are necessary for the preparation of one pound of meat, are easily lodged in the cellular tissue which surrounds the bone. Thence it forms a kind of reservoir, the liquid spreads penetrating all the fibres by infiltration, distributing regularly and homogeneously the conservative agent, and producing its first effect upon the parts most susceptible of alteration, that which surrounds the bone. The ham thus prepared is put for some days in a pickle-bath. The object of this bath is to prevent by its pressure, the issue of the liquid injected; besides which it completes the preparation by saturating the surface. When they leave the bath, the meat has lost nothing of the weight which it had at its entrance. I then expose it to a current of air at a moderate temperature. When by evaporation, they have lost the infiltrated liquid and 5 per cent. of their normal weight, I expose them to the action of smoke for a time which varies with their weight. This latter operation is not necessary for their preservation, but it gives them a taste which is generally sought for, and effects a reduction of weight. On leaving the smoke-house they have lost from 12 to 15 per cent. of their weight; before entering they had already lost about 5 per cent., so that their whole loss is from 18 to 20 per cent.—*Cosmos.*

For the Journal of the Franklin Institute.

Decision of the U. S. Patent Office on the Application of W. J. Cantelo for a Patent for Manufacturing Cordage, Paper, &c. April 15, 1862. Reported by H. Howson, Esq., Philadelphia.

On Appeal to the Examiners in Chief.

The applicant claims to have discovered that cordage, paper, &c., may be manufactured to advantage out of the hibiscus moscheutos, or hibiscus palustris, and he describes the process, in which there is no especial novelty, and claims a patent. The objections raised against his petition are threefold.

In the first place, it is said that a patent has been already granted to one Jean Blanc, 24th June, 1851, for the manufacture of cordage, &c., out of the okra plant, or hibiscus esculentus. This is of the same botanical genus as the hibiscus moscheutos, and it is asserted that in plants of the same genus, the resemblance between their properties is so uniform and so great, that those that are found in any one may be presumed to exist in every other of the same genus. This can hardly be said to hold true in all cases, nor in so large a proportion as to furnish any rule. The genera of plants are arranged according to certain distinguishing features in them, which by no means indicate their peculiar characteristics.

It is true, that in some cases those of a particular genus are, many

of them, found to possess common qualities. But this is by no means universally true. The vegetables of many of the genera are widely different in their virtues and powers. The broomcorn, for instance, would never lead any one to suspect the peculiar merits of the Chinese sugar cane, the sorghum saccharatum, although both are of the same genus. Many other examples of this might be named. And the number of species under each head is so great, that it would be entirely unsafe to infer the character of one from that of another, and unjust to deny invention to him who discovers in one, the properties which had before been known to exist in another. The application of J. B. Read, rejected 14th February, 1859, for making paper out of the okra plant, which was mentioned, must be disposed of upon the same considerations.

Reference was made also to William Johnson's English patent, No. 135, for 1855, for manufacturing paper, &c., out of plants of the order Malvaceæ, which embraces among several other genera that of the hibiscus. But if we cannot infer from the nature of one plant, that of another of the same genus, much less can we that of others of the same order. In fact, plants which possess hardly any useful properties in common, are frequently embraced under this division. It may well be questioned, therefore, whether a patent which supposes all the plants of an order to be capable of the same uses, can be valid. Certainly it cannot be, unless the supposition is true. Now there are many of the Malvaceæ which have no such supply of fibre, as to warrant any attempt to manufacture them into cordage or paper. Add to this the fact, established by affidavit, that the hibiscus moscheutos is not indigenous in England, and is known only as a rare exotic, if at all, and the supposition that it is embraced in the English patent, becomes manifestly preposterous. Another reason for disregarding the English patent is, the very large number of vegetables embraced in it. It cannot be well supposed, that any one person can have ascertained the nature of every species, included under the various divisions named, so as to ascertain how far each is available for the object in view. The conviction must force itself upon every one, that many of them are named merely from conjecture. To allow any one to monopolize the use of all that may come within the description, without distinguishing those that are of use from those that are not, is an abuse of the patent law, which ought not to be sanctioned.

It is further alleged, that the capacity of all vegetable fibre to be manufactured into paper has become so well established, that the selection of any particular plant for that purpose is no longer regarded as deserving of protection.

It has always been the practice of the Patent Office, notwithstanding, to reward any one who discovers that any particular plant possesses properties especially favorable for any manufacture. The patent of Jean Blanc shows this, and there are many others of the same kind.

It is considered that there is error in the decision of the Examiner, and it is reversed.

New Chronograph.

M. Lissajous presented to the Academy of Sciences of Paris, in his own name and that of Captain Schultz of the Artillery, a new instrument for measuring small intervals of time, by which he proposes to estimate accurately the five-hundred-thousandth part of a second. The instrument is to be composed (for it is not made yet) of, 1, A silvered drum about 40 ins. in circumference, which is to be coated with lampblack for the experiment: it makes three turns per second. 2, A tuning-fork giving five hundred vibrations per second, with the electric apparatus for preserving its vibrations according to the plan of M. Lissajous; a point fixed upon this, marks on the drum during the experiment. 3, An electrical apparatus to give a spark at the beginning and end of each phenomenon according to the plan of M. Martin de Brettes. That which characterizes the new apparatus is the length of the line on the drum, which corresponds to the very short duration of the phenomenon, and the facility of dividing it by the microscope.

Cosmos.

[This appears to be an improvement on the electric chronograph of Prof. Henry—described in the Proceedings of the American Philosophical Society, and which has been so extensively re-invented without acknowledgment in France, England, and elsewhere.

ED. JOUR. FR. INST.]

On the Manufacture of Strings for Musical Instruments, and other uses, of Gut and Sinew.

From the Lond. Mechanics' Magazine, December, 1861.

A manufacture of which comparatively little is known, is the preparation of the substance usually termed catgut, though for the most part made from the dried, twisted, peritoneal coverings of the intestines of sheep. Catgut cord is used for a variety of purposes where strength and tension are required, as for the strings of musical instruments, for suspending clock-weights, bow-strings for hatters use, and for archers bows.

The manufacture of musical strings requires a great amount of care and skill, both in the choice of materials and in the manufacturing processes, in order to obtain strings combining the two qualities of resistance to a given tension and sonority. Until the beginning of the last century, Italy had the entire monopoly of this trade, and they were imported under the names of harplings, catlings, lute-strings, &c.; but the trade is now carried out with more or less success in every part of Europe. However, in the opinion of musicians, Naples still maintains the reputation of making the best small violin strings, because the Italian sheep, from their leanness, afford the most suitable material; it being a well ascertained fact, that the membranes of lean animals are much tougher than those of high condition. The smallest violin strings are formed by the union of three guts of a lamb (not over one year old), spun together.

The chief difficulty in this manufacture is in finding guts having the qualities before mentioned—namely, to resist tension, and giving

also good vibrating sounds. It is far more easy to arrive at the proper point in the making of harp, double-bass, and other musical strings, and the manufacturer is not so much circumscribed in the choice of the proper material. The tension upon the smallest string of the violin, which is made of only three guts, is nearly double that on the second string, formed by the reunion of six guts of the same size.

In the preparation, the sheeps guts, well washed and scoured, are steeped in a weak solution of carbonate of potash, and then scraped by means of a reed cut into the shape of a knife. This operation is repeated twice a day, and during three or four days, the guts being every time put into a fresh solution of carbonate of potash, prepared to the proper strength. In order to have good musical strings, it is indispensable to avoid putrid fermentation; and as soon as the guts rise to the surface of the water, and bubbles of gas begin to be evolved from them, they are immediately spun.

In spinning, the guts are chosen according to their size; combined with three or more, according to the volume of the string required, they are fastened upon a frame, and then alternately put in connexion with the spinning-wheel, and submitted to the required torsion. This operation performed, the strings, left upon the frame, are exposed for some hours to the vapor of sulphur, rubbed with a horse-hair glove, submitted to a new torsion, sulphured again, further rubbed, and dried.

The dried strings, rolled upon a cylinder and tied, are rubbed with fine olive oil, to which one per cent. of laurel oil has been previously added. The oil of laurel is supposed to keep the olive oil from becoming rancid.

The gut-strings employed by turners, grinders, and for cleaning cotton, &c., are made with the intestines of oxen, horses, and other animals. These, cleared by putrefaction of the mucous and peritoneal membranes, and treated by a solution of carbonate of potash, are cut into straps by means of a peculiar knife, and spun in the same way as the musical strings. The uses of bladders and gut for holding lard, for covering gallipots and jars with preserves, as cases for sausages, polonies, &c., and other domestic purposes, are well known. Lately, however, the vegetable parchment, as it is termed (which is ordinary paper steeped in sulphuric acid), has come into extensive use for this purpose.

Insufflated, or inflated guts, are chiefly employed for the preservation of alimentary food. They have to pass through a long series of modifications and processes, before becoming fit for use. The end of these preparations is, to free the muscular membrane of the intestine from the two other membranes covering it, the peritoneal and the mucous.

The first operation of scouring consists in freeing, by means of a knife, the gut from the grease attached to it, and also of the greatest part of the peritoneal membrane. The scoured guts are washed and turned inside out, then tied together, put into a vat without any more water than that adhering to them, and left in this state to undergo a putrid fermentation. The time required for this operation will be from

five to eight days in winter, and two or three days only in summer. If the fermentation were pushed too far, the guts would be disorganized: to avoid this inconvenience, the workmen are often obliged to add some vinegar, in order to neutralize the ammoniacal compounds formed, and also because fermentation is slow in the presence of acids. After this fermentation, the mucous membrane is completely decomposed, and the remaining portions of the peritoneal membrane are easily taken off. The guts are then well washed, and insufflated (inflated).

This operation is performed in the same way as swelling a bladder, with this difference, that the extremity of the gut is tied by a ligature serving also to join a new gut insufflated (inflated) in the same way. During this operation, the guts exhale the most noxious smell, and workmen employed at such work could not blow or insufflate many days in succession without having their health affected.

In order to prevent that inconvenient, unhealthy process of manufacture, the *Société d'Encouragement* of Paris proposed a premium for a chemical process enabling the manufacturers of these articles to dispense with putrid fermentation. The process suggested by Mons. Labarraque, the successful candidate, is remarkable for its cheapness and the facility of its application. In following the method recommended by this chemist, these animal matters can be worked more easily, and kept for a longer time without evolving any noxious smell.

The guts, previously scoured, are put into a vat containing, for every forty guts, four gallons of water, to which $1\frac{1}{2}$ pounds (*Eau de Javelle*) oxichloride of sodium, marking 13° on the areometer of Beaumé, is added. After twelve hours of maceration, the mucous membrane is easily detached, and the guts are free from any bad smell; by this method, the process of insufflation is more easily performed.

The insufflated guts are suspended in a dry room until the desiccation is complete; and, once dried, the extremities by which they were tied together are cut, and in pressing the hand over the length of the insufflated (inflated) gut, the air inside is completely taken out. The guts are then submitted to fumigation by sulphur, in order to bleach and to preserve them from the attacks of insects. After this last operation, the guts are fit for use.

Besides our large home supply of bladders, we import several hundred thousand a year, packed in salt and pickle, from America and the Continent, and the aggregate value of the bladders used in this country is stated at £40,000 or £50,000.

The use of the reindeer-sinew for lashing and binding purposes on implements, &c., is common from Norway and Lapland, along the entire coast of Asia and America, even as low as 36° N. in California, and continued on the coast-line up to the easternmost point of America, and again at Greenland. Sir E. Belcher, in Transactions of the Ethnological Society of London, states that he traced this custom of using the reindeer-sinews continuously on the western coast as far south as the thirty-sixth parallel on the coast of California, where the Mexican Indians soak it and form it into layers, in which they enclose

the wood of the bow entirely. The horns of the bow are also moulded of it; and when dry, it presents the dull-grey translucent features of horn.—*The Technologist.*

For the Journal of the Franklin Institute.

Durability of Hemlock. By T. Guilford Smith, C. E. M. and B. M. Railroad.

To the Editor of the Journ. of the Frankl. Insti.

Sir:—In laying pipes to supply a water station on the top of the Broad Mountain, in Schuylkill County, on the line of the Mahanoy and Broad Mountain Railroad, we found it convenient to make use of the dam, and to follow the ditch originally made by the Danville and Pottsville Railroad Company, 32 years ago.

To our surprise, we found the hemlock trees which had been bored for pipes, in a perfect state of preservation, wherever submerged or surrounded by moist earth. The bark was still adhering, and the sap-wood presented that rosy hue seen in freshly felled hemlock. Wherever, on the contrary, the surroundings were dry, the timber was decayed.

The pipes varied in depth beneath the surface of the ground from $1\frac{1}{2}$ to 2 feet. They were in excellent condition for over 1000 feet in a continuous line.

Ashland, Penna., May 20th, 1862.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, May 15, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Letters were read from Col. H. Bache, Bureau U. S. Topographical Engineers, Washington, D. C., and Thomas Oldham, Esq., Superintendent of the Geological Survey of India, Calcutta.

Donations to the Library were received from the Royal Institution, the Royal Astronomical Society, the Institute of Actuaries, and the Statistical Society of London; Thos. Oldham, Superintendent of the Geological Survey of India, Calcutta; the K. K. Geographischen Gesellschaft, the K. K. Geologischen Reichenstalt, the Oesterreichischen Ingenieur-Vereines, and the Nieder-Osterreichischen Gewerbe-Vereines, Vienna, Austria; the Bureau of Topographical Engineers, and F. Emerick, Esq., Washington, D. C.; F. W. Bird, Esq., Boston, Mass.; Thomas Ewbank, Esq., City of New York; Dr. G. Emerson, A. B. Hutton, Esq., J. C. Beckel, Esq., Geo. R. Smith, Esq., Messrs. M. W. Baldwin & Co., Joseph Hutchinson, Esq., John C. Trautwine, Esq., and George M. Conarroe, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of April was read.

The Board of Managers and Standing Committees reported their minutes.

Candidate for membership in the Institute (1) was proposed, and the candidates proposed at the last meeting (9) were duly elected.

Mr. Howson exhibited a Bowie Knife, taken from Fort Donelson two days after the battle, and sent to W. F. Hall, Esq., of St. Louis. Mr. H. said that the weapon was well worth the attention of the members on account of the peculiarly crude workmanship displayed in its construction; that it was originally an ordinary file, and had a rough hickory handle and a guard attached to the shank.

Mr. Howson also exhibited specimens of the fibre of a plant termed *Hibiscus Moscheutos*, or *Palustris*, and remarked that he had shown similar specimens about a year ago, but now repeated the exhibition, owing to the importance attached to the discovery, not only by eminent naturalists, but by the authorities of the Patent Office, who have this week issued letters patent to Mr. Cantelo, the discoverer, and to his assignees, Messrs. Stuart and Peterson, for the exclusive use of the fibres of the plant in question, for the manufacture of paper, cordage, textile fabrics, matting, &c.* It would be a difficult matter to distinguish the specimens of rope made of this fibre from the best hempen rope, which it equals in strength and durability. Serviceable matting and excellent paper may be made from the fibre, which can, by the aid of proper machinery and appliances, be converted into valuable textile fabrics. The hibiscus moscheutos grows wild in the marshy grounds of most of the northern States, and is especially abundant in New Jersey.

A breech-loading Cannon, the invention of W. O. B. Merrill, Esq., of this city, was exhibited by Mr. Howson. To the rear of the barrel is permanently attached a yoke, in which works a movable breech, kept in its proper position in relation to the barrel by lugs, which project from it, and slide on ledges formed on each side of the yoke. To load the cannon, the breech is slid back, and tilted so as to expose the chamber, into which the cartridge is dropped. The breech is then brought to a horizontal position, pushed forward, and forced tightly against the rear of the barrel by a screw which passes through the yoke in a line with the bore.

W. W. W. Wood, Esq., Chief Engineer U. S. N., exhibited a model of his improved Armor for ships of war. His method of plating ships has been submitted to the leading engineers and ship-builders of the city, who have declared it superior to any of the numerous plans proposed for accomplishing the same object; the plating being stronger in proportion to the weight of metal, more economical, and capable of being attached to the sides with much greater facility than by other methods. The most important feature is the manner in which the plates

* See page 406, "Decision of the United States Patent Office."

are bolted to the vessel, without exposing the heads of the bolts where they can be struck by shot, thus rendering the stripping off of the plate by this means impossible.

George McIlvain, Esq., of this city, exhibited a Case for Gas and Hydrant Stops in pavements, made of terra cotta, much more durable than wood, and not liable to swell, so as to cause the top of the case to protrude above the pavement.

Jacob Ruth, Esq., exhibited an Apparatus for removing Invalids. It is an apparatus by which the heaviest person can be moved with ease by one person, with no pain to the invalid. Physicians who have used this apparatus in the Government hospitals, have pronounced it an important and valuable invention.

Mr. John W. Nystrom exhibited some specimens of Iron and Steel, manufactured at his establishment, Gloucester, N. J., by the process known as Bessemer's, and made the following observations:

The cast iron is smelted in an ordinary cupola, from which it is run into a barrel-shaped furnace, where air is blown into the molten iron for about 10 to 15 minutes, the time required for decarbonizing it to steel or wrought iron; after which it is run direct from the steel furnace into moulds of any desired shape. Ingots thus cast can be taken direct to a rolling mill or steam hammer, and worked in the one original heat.

The steel furnace now in operation is for acting on 3000 lbs. cast iron at a time, which gives about 2500 lbs. of wrought iron or steel. The specimens exhibited are, one steel plate of about $\frac{3}{16}$ inch thick, and one $\frac{5}{8}$ inch round iron bar, both of which are rolled out direct from ingots cast in sand moulds; also, one steel ingot and a piece of oxide of iron.

The cast iron thus far operated upon has been mostly the Allentown anthracite iron, No. 2, and two operations with charcoal iron. I am inclined to believe that, with some experience, good iron and steel may by this process be made from any kind of cast iron.

Armor plates can by this process be cast into any size and shape; also, cast steel and wrought iron guns, and a variety of articles made by the complicated and laborious process of puddling, rolling, welding, and forging, can by this process be made into shape of the purest iron or steel in one heat. The great heat generated in the steel furnace enables the decarbonized iron to remain for some time in a perfectly fluid state, allowing the lighter impurities to rise to the surface in form of slag, and the pure metal to run into moulds. In puddling furnaces, the decarbonized iron cannot attain so high a heat as to be kept in a fluid state, but of the consistence of dough, intermixed with and rolling in a fluid slag, which is partly squeezed out under a hammer or squeezer, after which the iron bloom is rolled out to a bar. This bar is cut in pieces, piled up into a packet, heated and rolled, which operation is repeated several times before good iron is obtained, and every time the iron passes through the rollers, slag is squeezed out of it; while by the process known as Bessemer's, the ingots roll-

ed out to finished iron in the first original heat, slag is hardly perceptible.

The Bessemer process has in the last five or six years gone through the different stages of success, failure, ridicule, and criticism, customary to every good thing, and is now in successful operation in several places in England and Sweden. The only difficulty I have to contend with in carrying on the process is the want of capital; as it is a new thing in this country, it is hard to convince capitalists of its great importance.

A great many parts of machinery which in Europe are made of wrought iron or steel, are in this country made of cast iron; now, by this process, such parts can be cast direct of steel or iron, which will materially reduce the weight and increase the durability of the machinery. I consider the process to be of the greatest importance for railroad iron, such as wheels, tyres, frog-plates, rails, &c. I am inclined to believe, that by this process cast steel rails can be made at the same price as that of the present puddled rails. Such cast steel rails would not only stand perhaps four times as long as iron rails, but it would increase safety and comfort on the road in the same proportion.

Samuel Sartain, Esq., engraver, of this city, exhibited an impression of a large Map, devised and executed on a new and effective plan by Col. Baron Egloffstein, U. S. A. It illustrates the labors of the U. S. expedition for exploring the *Colorado River of the West* and surrounding country in New Mexico.

Baron Egloffstein, the topographer of the expedition, conceived the idea of endeavoring to give his map the appearance of a small plaster model of the country; and to do this he treats the forms of nature as an artist would draw any form before him—that is, by giving the real light and shade that would be developed by light falling on the model at a suitable angle. The mountains have their shadow-side engraved in the usual manner by "*hachures*," but the light-side is only slightly tinted in parts to develop detail of form, and is brilliantly relieved by a tint spreading over the level plain like an India-ink wash; this tint is made of several grades of strength, intended to show the *relative altitude* of the several plateaus over which it is spread, the lowest or alluvial lands having the darkest tint, and the loftiest table-lands having the most delicate.

The result in the present map is bold and striking, showing at a glance the nature of the whole country, enabling any one to perceive the character, prominence, and relation of the different parts. This region of country has features unsurpassed in their kind for grandeur and sublimity; the Colorado of the West flows for 300 miles of its course through Cañons whose sides often rise perpendicularly from 3000 to 6000 feet in height; the "Great Cañon of the Colorado" is the most magnificent gorge as well as the grandest geological section of which we have any knowledge. For this region, Col. Egloffstein's system of mapping has unquestionable advantages; its freedom from conventionality and truth to nature, give it a power, unattainable by

the old system, of representing forms so that they are intelligible to every eye.

The French at one time used a system of topography similar to this; it had light-sides and shade-sides to the mountains, but they did not tint the level plain, on which so much of the character and beauty of this style depends. The tint on the steel plate shown, is machine-ruled (nearly 200 lines to the inch), and graded to the requisite strengths by acid, giving by its fineness the appearance of delicate India-ink tints; this portion of the work was executed by Mr. Samuel Sartain, and excels as a specimen of this method of engraving.

Col. Egloffstein deserves the thanks of the *public* for enabling them to read some of the results of scientific labors with an *ease* that was before only possible to the professional topographer, and at perhaps less expense than by the old system.

Mr. A. L. Fleury read the following paper:

My esteemed friend, Mr. Frederick Ruschhaupt, a very able technical chemist of Berlin, has lately patented a most simple, economical, and useful Apparatus for generating Carbonic Acid and other gases; he has forwarded to me the drawing which is here exhibited.

The apparatus consists of a strong wooden tub or vessel, 2 feet high and 17 inches wide, having a partition near the middle. The whole inside of both partitions is lined with lead. From the upper part of the wider partition a leaden pipe leads near to the bottom of the smaller partition. A leaden vessel, perforated with holes at the bottom, is filled with carbonate of lime, marble pieces, say 6 lbs., and dipped by means of a sliding rod into the larger partition, containing about 7 lbs. of hydrochloric acid. The other (smaller) partition is half filled with pure water, having a glove-valve as outlet. The vessel is closed air-tight by a strongly braced cover.

Whenever a supply of carbonic acid is desired, the lead vessel containing the marble pieces is slid into the acid, which, passing through the leaden tube, under and through the water in the next partition, to the glove-valve (for the purpose of purifying the gas from any foreign matter or chlorine carried over with the carbonic acid), is by means of suitable pipes conveyed wherever it may be desired. When the marble, which is a chemical combination of lime with carbonic acid (56·09 lime with 43·91 carbonic acid), is dipped into the hydrochloric acid, the carbonic acid is thereby expelled, the lime combining with the chlorine to form chloride of lime, which, after all the carbonic acid is expelled, can be taken from the gas apparatus by a syphon without taking off the cover, and may afterwards be used for the purpose of bleaching, &c.

Six pounds of marble dust and seven pounds of hydrochloric acid will furnish about 170 *gallons of carbonic acid gas; and all this at a cost of about* 18 *cents!*

There is no danger of explosion, as in the ordinary copper apparatus, because the pressure can never rise sufficiently high, and the evolution of gas can be stopped at any moment by withdrawing the sliding

rod which dipped the marble into the acid; moreover, if desired, though not imminently necessary, a safety valve as well as pressure gauge may be put on. The beautiful simplicity of the apparatus, its safety, its easy management by the most ignorant person, *and above all, its low price*, making it accessible to all classes, are the best recommendations to the public at large.

I will here enumerate some of the most prominent applications. The hot season is now upon us, and who is not fond of a fresh and sparkling glass of soda water or lager beer? The gradual loss of carbonic acid in lager beer causes this beverage to become bitter and of a disagreeable taste; it makes it unwholesome and productive of headache. Some men, not familiar with the chemical requisites of good, healthy beer, attempt to overcome this evil by injecting atmospheric air—the very means of forcibly driving off what they should most necessarily keep in.

By means of this cheap gas apparatus, lager beer can not only be kept continually fresh and impregnated with carbonic acid gas, but also by a proper arrangement of tubes forced up by it, fresh and sparkling to the last drop. The same may be applied to soda water, lemonade, wine, and other beverages.

I would here draw attention to the adaptability of Mr. Ruschhaupt's gas generator for the easy preparation of ferro-carburetted water, a water containing oxide of iron in solution. This peculiar beverage is considered by some eminent European physicians a powerful preventive and remedy for debility; even cases of consumption are said to have been cured.

The manufacturers of white lead, of bicarbonate of soda, of hydrate of silica, and others, may perhaps find this apparatus more convenient than their present arrangements.

Bakers and hotel keepers are thereby enabled to prepare the finest and most wholesome aërated bread, without yeast or soda powders, more effectively and cheaper than in the present way.

The chemist will find this apparatus of great value in his laboratory: its use is not confined to carbonic acid gas alone; hydrogen, chlorine, sulphuretted hydrogen, hydrocarbons, and other gases can thereby be most economically and speedily evolved.

The same gentleman has invented an excellent apparatus for producing Artificial Ice, by exhausting and compressing ammonia gas in a separate vessel, now exploited by a New Haven company. I hope Mr. Ruschhaupt may be able, by proving the priority of his invention, to reap some benefit for his arduous labors.

Mr. John Warner submitted to the meeting his Stereometric Tablet, together with diagrams showing his new system for the computation of earthwork (which subject he has more fully shown in a work published by him*), and made the following explanation:—

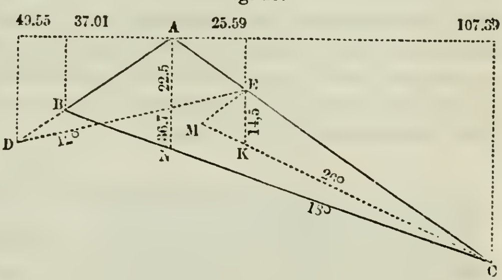
* New Theorems, Tables, and Diagrams, for the Computation of Earthwork: designed for the use of engineers in preliminary and final estimates, of students in engineering, and of contractors, and other non-professional computers. Illustrated by original engravings, and a series of lithographic drawings from models showing all the combinations of solid forms which occur in railroad excavations and embankments. Octavo, 316 pages. Philadelphia, J. B. Lippincott & Co., 1861.

The Stereometric Tablet is intended to assist computation of earthwork by the method of Transverse Ground-Slopes. This method is much used for preliminary estimates. The measurements taken on the field are, the length of the work, and, at each end, the centre-height, and the inclination to the horizon of the surface-line of the cross section. We shall assume the surface-line of the cross section to be everywhere straight, and the surface of the ground to be a warped surface, generated by the motion of this straight line moving parallel to the vertical end planes of the work, and resting upon two straight directrices. These directrices are supposed to be the outside bounding lines of the ground surface.

In order to exhibit the cubature of the solids in question, we shall suppose both the end cross sections to be plotted in the same figure. We shall, at first, consider the whole cross section which is formed by prolonging the side slopes until they meet—that is, we shall consider the whole solidity contained between the ground surface and the intersection of the side slopes.

Let A B C, fig. 45,* represent one entire end cross section, and A D E the other. Through E, the point where the side slope A C of one end is cut, on the drawing, by D E, the surface slope of the other end, draw E M parallel to the other side slope, and make E M = B D, the difference in length of the side slopes A D and A B. Join M with the angle C, and draw the vertical line E K. The height E K, and the inclination of C M to the horizon (or the surface slope of C M), may be easily measured on the diagram. A similar and equivalent result will be obtained by drawing a line B M through B, making B M parallel and equal to E C, joining D M and drawing B K. The construction is not shown in the figure.

Fig. 45.



The solidity, as we have elsewhere shown, consists of two terms. The first, or principal term, is a prism having the same length as the work, and for its base the whole cross section taken in the middle of the work. This cross section is readily found by a construction which we shall briefly indicate.

Bisect B D and E C, and join the two points of bisection; the line joining them will be the surface of the mid-section. The height to this surface, and its slope, can then be measured.

The second term of the solidity is the *one-twelfth* part of a prism of the same length, and standing on the base, C M E. This second term may be called the *correction*, because the first term may be con-

*This figure has been transferred from the stereotype plates of the writer's treatise, and contains some lines not necessary to our present purpose. In order not to make similar transfers too frequent, we have been obliged to avoid entering here at greater length into the mathematical theory of our subject.

sidered as an approximate result, which may be corrected, if desired, by means of the second term. The correction is additive if the directrices are inclined in the same direction, otherwise it is subtractive. Whenever A B = A D or A E = A C, the correction vanishes.

The computation of solids under the warped surface proposed, is, therefore, reduced to the computation of solids under plane surfaces. When the surface slope is the same at each end of the work, the ground surface becomes a plane. In this case, C M has the original slope of the ground, and E K = the difference of the centre-heights.

We shall now consider the method of finding the solidity of a prismoid or prism by means of the Tablet. This being done, the solidities of the two prisms above described may be found, if required.

Let L = the length of the work, B = the width of road-bed, S = the sum of the whole heights similar to A N, at each end of the work (called *augmented centre-heights*), and let D = the difference of these heights. Also, let the side slope, or angle C A 107·39 = σ, and the surface slope, or inclination of C B to the horizon = γ. Let V be the volume of the prismoid contained between the ground surface and the road-bed: then our formula is

$$V = \tfrac{1}{4} L \left(S^2 - B^2 \tan.^2 \sigma + B^2 \tan.^2 \gamma + \frac{D^2}{3}\right) \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma} \quad . \quad . \quad \text{(A.)*}$$

If the width of road-bed and the difference of the centre-heights be made both = 0, that is, if B and D be both = 0, we shall have an expression for the solidity of a prism whose base is the whole cross section between the surface and the intersection of the side slopes. The formula will then become

$$V = \tfrac{1}{4} L S^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma} \quad . \quad . \quad . \quad . \quad . \quad \text{(B.)†}$$

If the square root of the quantity within the parenthesis, in equation A, be put = S_1, then that equation may be put under the form

$$V = \tfrac{1}{4} L S_1{}^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma} \quad . \quad . \quad . \quad . \quad . \quad \text{(C.)}$$

Equations B and C are evidently of the same form. The quantity S_1 may readily be found by a construction which we shall not now describe. Hence the resolution of equation B or C by means of the Tablet, will suffice for computing prismoids under plane ground, or the first and second terms above required for work under a warped surface.

Equation B may be put under the form

$$V = \tfrac{1}{4} L S^2 \frac{\cot. \sigma}{1 - \dfrac{\tan.^2 \gamma}{\tan.^2 \sigma}};$$

* See Treatise, page 281.

† It may be observed that the writer's "Computation of Earthwork" contains tables from which the value of V, for several of the most usual side slopes, and for L = 100 feet, can be immediately found for given values of S and of γ. By the aid of other tables, V can be found by logarithmic computation.

in which, because σ is always greater than γ, we may replace $\frac{\tan.\gamma}{\tan.\sigma}$ by the sine of an auxiliary angle. Putting $\sin.\varphi = \frac{\tan.\gamma}{\tan.\sigma}$, that is, $\sin.\varphi = \cot.\sigma \tan.\gamma$, the above equation becomes

$$V = \tfrac{1}{4} L S^2 \frac{\cot.\sigma}{1 - \sin.^2\varphi} = \tfrac{1}{4} L S^2 \cot.\sigma \sec.^2\varphi. \quad . \quad . \quad (D.)$$

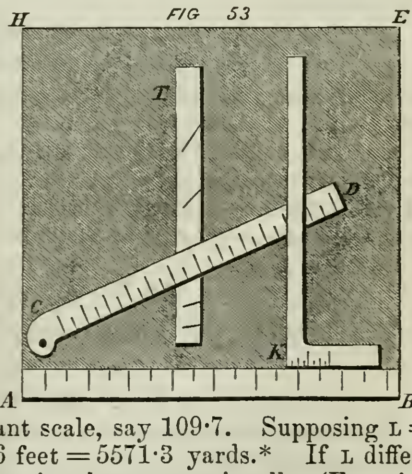
If A be the area of the base of a square prism, having the same length and the same solidity as the prism represented by equation D, then we have the equality $L A = \frac{1}{4} L S^2 \cot.\sigma \sec.^2\varphi$, whence the side of the square base is

$$\sqrt{A} = \tfrac{1}{2}\sqrt{\cot.\sigma}\, S \sec.\varphi.$$

We do not design, however, to employ the quantity $\sqrt{A}$, but in its stead $\sqrt{A}\sqrt{8}$. With this we shall enter a table containing the tabular quantity $\frac{1}{8} L(\sqrt{A}\sqrt{8})^2 = L A$, the content of the prism. It only remains to find $\sqrt{A}\sqrt{8} = \sqrt{(2\cot.\sigma)}\, S \sec.\varphi$, by the Tablet. The equation $\sin.\varphi = \cot.\sigma \tan.\gamma$, permits a ready construction of the angle φ. First take radius $= \cot.\sigma$ and, with this radius, find $\tan.\gamma = \sin.\varphi$. Then with radius 1 take $\sin.\varphi$ and construct φ. If S be taken for radius, then $S \sec.\varphi$ will be shown by the secant of the angle φ. In order to obtain $\sqrt{(2\cot.\sigma)}\, S \sec.\varphi$, the secant shown by the Tablet must be measured by a scale, so graduated that the absolute length of its unit is to the length of the unit of S, as $\frac{1}{\sqrt{(2\cot.\sigma)}}$ to 1.

In the figure, A B E H is a flat tablet. The scale C D is the secant scale, movable about the pivot C, and is graduated as above described. It is set to its place by aid of the tangent scale T, which indicates the angle φ. The scale A B measures the sum of heights S, to which the square K, sliding against A B, is set. The back of the square contains a vernier, which reads to tenths of feet. The blade of the square marks the end of the secant upon the secant scale. Thus, if the side slope be $1\frac{1}{2}$ to 1, the surface slope 15°, and the sum of heights be 58, we shall read on the secant scale, say 109·7. Supposing L = 100 feet, $\frac{1}{8} L (109{\cdot}7)^2 = 150{,}426$ feet $= 5571{\cdot}3$ yards.* If L differs from 100 feet, our tabular content is taken proportionally (Equation B). The diagram represents this example.

FIG 53



If the surface slope is level, and the sum of augmented centre-

*See the example in Treatise at the bottom of page 48. The quantity 5571·3 will be found in table xv., opposite 109 feet, and under seven-tenths.

heigths $= S_2$, we may find the solidity of the prism with level surface slope from equation B. Then equating the value thus found with that given in equation D, we may find the sum of *equivalent level heights*, that is, a sum of equal heights which, under level ground, contain the same solidity as the prism under sloping ground. We shall have

$$\tfrac{1}{4} L S_2^2 \cot. \sigma = \tfrac{1}{4} L S^2 \cot. \sigma \sec.^2 \varphi,$$

whence,

$$S_2 = S \sec. \varphi.$$

Hence, if the scale C D be graduated like A B, by taking S upon A B we shall find S_2 upon C D; say, in the above example, 63·3. Hence, equivalent level heights may be correctly employed to compute the solidity under the proposed warped surface. We shall not here describe the manner in which we have applied this method.

By means of the Tablet, a sum of heights may be found which will contain, under a given surface slope, the same solidity as another given sum of heights under another given slope. Thus, suppose E K (fig. 45) to have been found $= 14·5$, and the slope of C M $= 26°$. Required the sum of equal heights which shall contain, under a slope of 8°, the same solidity as the prism upon C M E. The sum of two equal heights, E K, is 29. Set the square, K, of the Tablet at 29, and set the secant scale, C D, at 26°. Then read on this scale, say 73·7. Set the scale, C D, at 8° upon the tangent scale, T, and set the square, K, at 73·7 on C D. Then read the distance marked by the square upon A B, say 41·6, for the new sum of heights required. We shall presently want to make use of this number.

Put the augmented centre-height of the mid-section $= \tfrac{1}{2} S$, and its surface slope $= \gamma$. The solidity of the prismoid standing on that part of the mid-section included between the surface and road-bed will be, by formula C,

$$\tfrac{1}{4} L S_1^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma},$$

which is the first term for the solidity of the work contained under the warped surface.

Let the height, similar to E K (fig. 45), which would contain the same solidity under the surface slope γ of the mid-section, as is contained in the prism on C M E, be put $= D_1$; then the sum of heights is $2 D_1$, and the solidity is, by formula B,

$$\tfrac{1}{4} L \, 4 D_1^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}.$$

The *correction* will be one-twelfth of this, equal to

$$\tfrac{1}{4} L \frac{D_1^2}{3} \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}.$$

Combining this last with the expression just found for the first term, and observing that the correction may be either additive or subtractive, we have, for the solidity between the warped surface and the road-bed,

$$V = \tfrac{1}{4} L \left(S_1 \pm \frac{D_1^2}{3} \right) \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}.$$

Making $S_1^2 \pm \frac{D_1^2}{3} = S'^2$, we have

$$V = \tfrac{1}{4} L S'^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}. \quad . \quad . \quad . \quad . \quad (E.)$$

Which is of the same form as equation B, and may be resolved by the Tablet in the same way. Equation E may also be resolved by equivalent level heights, or by any of the processes which, in our treatise, we have given for equations of this form.

As an example to be worked by the Tablet, take the following:*

First end-height, —28·7; surface slope, 18° to the right; second end-height, —14·5; surface slope, 12° to the left; side slope, $1\frac{1}{2}$ to 1; road-bed, 24 feet; length, 100 feet. Required the solidity between the surface and road-bed (fig. 45).

The augmented height of the mid cross section will be found by construction = 34·96, which gives the sum $S = 69·9$. The surface slope will be found 8°. Then by construction we find, according to equations A and C, $S_1 = 68·13$. We have found above for a prism equal to that upon C M E, and having a slope of 8°, the sum of the centre-heights $= 41·6 = 2 D_1$; hence, $D_1 = 20·8$. The correction is subtractive; hence, $S' = \sqrt{S_1^2 - \frac{D_1^2}{3}}$ may be found by construction = 67·06.

Then set the square K, of the Tablet, at 67·06, and the scale C D at 8°, and read upon C D the distance, say 118·8. Then, $\frac{1}{8} L (118·8)^2 =$ 176,418 feet = 6534 yards, which may also be found by our table XV.†

As the Tablet is only the mechanical adaptation of constructions we have taught in our work, this cubature is a geometrical solution for the warped surface proposed.‡ If the correction be neglected, the operation of the Tablet is very expeditious. The auxiliary constructions will be facilitated by the use of permanent diagrams, for which, in our treatise, we have given the rules of construction, and which can be rapidly prepared by an expert draughtsman.

The Tablet can be formed by pasting a paper scale, A B, upon the edge of a drawing table. The square K may be supplied by a T square applied to the edge of the table. The scales T and D may also be made of paper. The scale T should have its zero upon a line drawn through the pivot C, parallel to A B, which should also count from C. Means will readily be found to change these scales when a new side slope is employed. The writer has, for the tangent scale, made use of a polygonal roller let into the Tablet. On the faces of this roller, various scales may be graduated.

It is possible to reduce work having a triangular cross section, as in hill-side work, to a form proper for computation by the Tablet. In such cases, we may suppose A D (fig. 45), which may be imagined horizontal, to represent the road-bed, and A C the side slope: B C will be the surface. Then bisect the angle B A C, and measure the height A N.

* See Treatise, Example 2, Article 104, page 53; and Article 6, page 294.

† If considered preferable, the correction may be made by taking one-third of the tabular quantity corresponding to E K and the slope C M, as shown on page 294; using the Tablet.

‡ See Plate XIV. of Treatise, and text, Articles 23, 24, 25, Appendix.

This might be facilitated by drawing A N (sufficiently prolonged) on a permanent diagram, and graduating a scale upon this bisecting line. A line perpendicular to A N would represent the horizontal, in regard to the measurement (for the construction of the scales C D and T of the Tablet) of the side slope and the surface slope. This line would bisect the real angle of side slope. The surface slope which is to be used for constructing the scale T being called γ', and γ being the real surface slope, then $\gamma' = \gamma - \frac{1}{2}\sigma$. The level surface, as concerns the scale, will be when $\gamma = \frac{1}{2}\sigma$; this will produce the zero of the scale, or $\varphi = 0$. But this point must be marked with the original surface slope, $\gamma = \frac{1}{2}\sigma$, and so on. Two graduations will thus arise, one counting up the scale, the other down it. Each division of the scale should be marked with the degree of original surface slope to which it corresponds.

If the correction is omitted, or if the surface is plane, only the sum S_1 (equation C) will be required to be found by construction. The operation by the Tablet is then easy. As the accurate computation for plane ground is simple, we would not, when the ground is plane, or assumed to be so, reject the *correction* in practice. But for warped surfaces, we think it may answer to compute only the first term, or the prismoid standing on the mid area. For it must be observed, that the warped surface has not been demonstrated to enclose a solidity more nearly approximating the actual content of the ground than any other surface determined by the same data. In the absence of a demonstrated theory, it is even possible that the prismoid standing upon the mid area of the warped surface may, in the long run, be as good an approximation to the true solidity of the work, as the solid under the warped surface. The doubt which rests on the choice of the warped surface, justifies, in the writer's opinion, some remission of the labor of computing accurately under it, especially for preliminary estimates. Similar considerations would, of course, apply to other surfaces. As long as there is neither a demonstrated theory nor an authoritative decision to guide, engineers must, it seems to us, depend on individual judgment and experience, to determine when rules of computation are sufficiently accordant with the law of the assumed surface, and, also, when assumptions regarding the surface are sufficiently correct.

We do not, however, propose to enter here into a formal discussion of the most probable hypothesis concerning the ground surface, but shall merely further observe, that experience has convinced us that, whether a satisfactory hypothesis can be found, or not, it will be difficult to introduce into general practice, rules for earthwork computation, which are either very laborious, or which require a constant and considerable exercise of inventive faculty in their application. Hence, we are of opinion that rules for ascertaining, by preliminary calculation, under what circumstances this or that hypothesis is to be employed, will prove a failure in practice. It will be easier to divide the ground into shorter sections, and compute them by a uniform process. In the formation of practical rules, we have endeavored, both by study and by oral consultation, to ascertain the wants of the practical man, and to reconcile them with the theoretical exigencies of the subject.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

APRIL.—The mean temperature of April, 1862, was about $3\frac{1}{2}°$ below that of the same month of 1861, and $1\frac{1}{2}°$ below the average temperature of the month for eleven years.

The warmest day of the month was the 18th, of which the mean temperature was 70°, the maximum temperature (82°) being reached on the same day.

The coldest day was the 9th, with a mean temperature of 33·2°. The minimum (28°) was attained on the same day.

The range of temperature for the month was 54°.

The temperature was below the freezing point on but 3 days of the month, namely, the 8th, 9th, and 10th.

The greatest change of temperature in the course of one day was 27° on the 17th day of the month; the least was 7° on the 21st. The average daily oscillation of temperature (17·87°) was a little more than one degree less than that of April, 1861, and about one degree more than the average for eleven years.

The greatest mean daily range of temperature (that is, the greatest average difference of temperature between one day and that immediately following or preceding it), was 14°, between the 18th and 19th of the month; the least was 1·8°, between the 26th and 27th. The average daily range for the month (5·89°) was almost identical with that for April, 1861, and was about half a degree below the average for eleven years.

The pressure of the atmosphere was greatest (30·321 inches) on the morning of the 16th of the month; and least (29·422 ins.) on the afternoon of the 22d. The greatest daily mean pressure (30·300 inches) occurred on the 15th, and the least (29·439 inches) on the 22d. The average pressure for the month (29·999 inches) was 0·183 of an inch greater than for April, 1861, and 0·194 of an inch greater than the general average for eleven years.

The greatest mean daily range of atmospheric pressure was 0·3 of an inch, and occurred between the 21st and 22d days of the month; the least was 0·044 of an inch, between the 26th and 27th. The average mean daily range for the month (0·146 in.) was 0·025 of an inch less than the average for April for eleven years.

The force of vapor was less than usual. It was greatest (0·555 in.) on the 18th, and least (0·091 in.) on the 7th of the month. The average for the month (0·219 in.) was about two-hundredths of an inch less than the general average.

The relative humidity was greater than for April, 1861, but less than the average for eleven years. It was greatest (94 per cent.,) on the morning of the 9th of the month, during a snow storm, and least 18 per cent.) on the afternoon of the 27th. The average humidity of

for the month was about 2 per cent. more than for April, 1861, and 3 per cent. less than the general average for eleven years.

Rain or snow fell on eleven days of the month, to the aggregate depth of 3·947 inches, which is one-fifth of an inch less than fell in April, 1861, and nearly one inch less than the average amount for eleven years.

There were three days of the month, the 11th, 12th, and 27th, entirely clear or free from clouds at the hours of observation, and the sky was completely covered with clouds at those hours on five days. The average amount of the sky covered with clouds during the month of April, 1862, was about 62 per cent.; during April, 1861, it was 53 per cent., and the average amount for eleven years is 60 per cent. of the hemisphere.

A snow storm commenced about 9 A. M. on the 8th, and continued until 8 A. M. on the 9th, when there was about three inches of snow on the ground. It commenced again about half past 2 on the afternoon of the 9th, and continued until 6¼ A. M. of the 10th, when the snow had attained the depth of about 12 inches. This was the last snow of the season.

A Comparison of some of the Meteorological Phenomena of April, 1862, *with those of* April, 1861, *and of the same month for* eleven *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich.

	April, 1862.	April, 1861.	April, 11 Years.
Thermometer.—Highest,	82°	88°	88°
" Lowest,	28·0	33	20
" Mean daily oscillation,	17·87	19·05	16·89
" " daily range,	5·89	5·85	6·40
" Means at 7 A. M.,	44·57	47·18	45·63
" " 2 P. M.,	55·23	60·55	57·51
" " 9 P. M.,	48·28	51·10	49·45
" " for the Month,	49·36	52·94	50·86
Barometer.—Highest,	30·321 in.	30·233 in.	30·518 in.
" Lowest,	29·422	29·213	28·884
" Mean daily range,	·146	·143	·173
" Means at 7 A. M.,	30·025	29·845	29·824
" " 2 P. M.,	29·979	29·787	29·782
" " 9 P. M.,	29 994	29·816	29·808
" " for the Month,	29·999	29·816	29·805
Force of Vapor.—Means at 7 A. M.,	·211 in	·231 in.	·233 in.
" " " 2 P. M.,	·219	·226	·247
" " " 9 P. M.,	·228	·259	·250
" " " for the Month,	·219	·238	·243
Relative Humidity.—Means at 7 A. M.,	67·8 per ct.	66·9 per ct.	71·8 per ct.
" " " 2 P. M.,	48·5	42·3	51·3
" " " 9 P. M.,	64·5	65·3	67·5
" " " for the Month,	60·3	58·2	63·5
Rain and melted snow, amount	3·947 in.	4·150 in.	4·799 in.
No. of days on which rain or snow fell,	11	9	12·8
Prevailing winds—Times in 1000-ths,	N.45°0′ E. ·047	N.73°30′W·177	N.68°5′ W.·161

BIBLIOGRAPHICAL NOTICE.

A Report of the Lighthouse Board in relation to the Transfer of the Lighthouse Establishment to the Navy Department. 37 Cong., 2d Sess., Senate. Mis. Doc., No. 61.

In the year 1851, the lighthouses of the United States were in a condition which was disgraceful to our country. Along the whole of an extremely exposed and dangerous coast, there were in all but 325 lights; of which one was ranked as of the 1st, two of the 2d, and 16 of the 3d order. But these were of the old reflector pattern, which had been long abandoned by the maritime nations of Europe for the refracting system introduced by Fresnel. Organization of the service there could scarcely be said to be any. The whole matter was under the control of one of the Auditors of the Treasury Department, whose other duties were quite as much as he could attend to; and, as the management of the lighthouses brought with it less political influence than any other branch of his duties, it was of course entirely neglected, except to give a favorite supporter a fat contract for furnishing oil in wasteful quantities at unheard-of prices.

When we consider how important an efficient system of coast-lights is, as well to the pecuniary interests of our merchants as to the character of the nation itself as one of the community of civilized nations, we will easily understand that this state of things was bitterly complained of, and so in 1845, two intelligent officers of the Navy were, at the request of the Hon. R. J. Walker, then Secretary of the Treasury, detailed to visit and examine the lighthouse systems of England and France; and afterwards, in 1851, another commission was appointed to examine into the lighthouse establishment of the United States. It will be seen that the matter was not hurried. But upon the report of this latter commission, Congress passed an act establishing the Lighthouse Board, consisting of "two officers of the Navy of high rank; one officer of the corps of engineers of the Army; one officer of the corps of topographical engineers of the Army; and two civilians of high scientific attainments, whose services may be at the disposal of the President; and an officer of the Navy, and an officer of engineers of the Army as Secretaries."

The two civilians appointed on the Board were Prof. A. D. Bache, Superintendent of the Coast Survey, and Prof. Joseph Henry, Secretary of the Smithsonian Institution.

The propriety of the appointment of just such a board as is here provided for will be seen by a moment's reflection on the requisites of the service. The first point is to arrange the approximate positions of the lighthouses, so as to insure general security along the whole coast, as well as a special care for the safety of any peculiarly dangerous positions. This falls within the province of the Navy, although it would seem that it might be at least as well done by the Revenue Department, or by two merchant captains of the coasting trade. The next point is the selection of the precise site for the lighthouse; and as this requires an intimate knowledge of the coast, both inland and within soundings; of the position, extent, and depth, of all shoals and

banks, and a minute acquaintance with the force and direction of all the currents, both constant and temporary, in the vicinity of the locality, there is but one place in the whole country to which we can apply for the requisite information, and that is the Coast Survey. When the locality is determined on, the next point to be attended to is the erection of the tower, and this requires such thorough and extensive engineering ability, that not a few of the great engineering reputations of England have for their foundation the successful establishment of lighthouses in difficult positions. The next and most important point is the light itself, wherein are to be considered several problems: to obtain the most intense light; to concentrate it into a parallel or slightly divergent beam; to avoid throwing any part of it away in directions where it can be of no use, such as upwards, downwards, or landwise; to prevent as far as possible the absorption of it by the apparatus used for concentrating it; to give it such a character that it may be readily distinguished by the mariner, so that when he sees the light he may know exactly whereabouts on the coast he is. Now these are problems of Physics; they lie neither in the province of the engineer, the mariner, nor the surveyor. They are problems whose solutions are being every day more and more perfected by observations and experiments and discoveries taking place in all parts of the civilized world. To meet this want, then, we require a man of high scientific ability and attainment, one who is accustomed to read all the scientific journals of the world, so that no discovery can escape him; and one who is himself able experimentally to test the correctness of results said to be reached, and to develop such new ideas as may occur to himself; and, in addition, one who knows the abilities of the various scientific men of our country, so that he may employ their knowledge and facilities where it may be desirable to use them. Such a man pre-eminently is Prof. Henry.

It appears, therefore, *à priori*, that the lighthouse board was judiciously constituted; it appears so still more clearly from the facts reported to the Senate in the document before us.

The number of lights has been increased from 325 in 1852 to 556 in 1858; the character of the lights has been improved by the introduction of all the last improvements, so that in place of being a disgrace to the nation, our system will now favorably compare with those of England and France; yet, notwithstanding this greatly increased number and efficiency of the lights, the cost of maintaining them was less in 1858 than in 1852 by $184,720. The whole system has been organized, a proper superintendence established over the keepers, so as to insure the utmost efficiency and regularity in each light, a matter which can hardly be properly appreciated except by the mariner.

Let us hope, then, that seeing how admirably their experiment has succeeded and is succeeding, and having regard to the fact that this wicked rebellion has extinguished 125 lights, many of them of the highest importance, which must be immediately replaced,—let us hope that Congress will not be induced to make any change whatever in the lighthouse department, until they are thoroughly satisfied that there is an evil to be remedied, and that the remedy which they propose to apply is the right one.

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